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WINTER OBSERVATIONS ON THE SIERRA NEVADA BIGHORN SHEEP[1]

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Sierra bighorn sheep were studied on their winter ranges on the east slope of the Sierras. Ranges are characterized by rugged granite terrain. Reproduction rates were relatively low. Bitterbrush, California buckwheat, green ephedra, and needlegrass were the most important foods. Nutritional content was high except for phosphorus. Sheep harbored moderate infestations of lungworms and lambs also showed infection with *Nematodirus*. Ranges of deer, elk, and cattle barely overlapped the bighorn ranges and forage competition was absent. Potential population controls are discussed.

INTRODUCTION

The low number of Sierra Nevada bighorn sheep (*Ovis canadensis californiana*) is of special concern to conservationists. This is the last substantial herd of the race *californiana* remaining in the United States, although good populations still exist in British Columbia (Buechner, 1960). Because of the extremely rugged terrain and difficulty in finding the animals, little is known about the ecology of the Sierra Nevada bighorn. Jones (1950) made a survey in the summer of 1948, at which time he estimated the population to be 390 animals. Other than Buechner's (1960) brief reconnaissance, the only subsequent work is Riegelhuth's (1965) report of the locations of some important winter ranges.

Our field work extended from February through March, 1964, and January through May, 1965. Most of the canyons which might serve as winter ranges for the Mt. Williamson and Mt. Baxter herds, the two largest according to Jones (1950), were surveyed. However, most effort was directed to the range of the Mt. Baxter herd, from Thibaut Canyon to Sawmill Canyon where the greatest numbers of bighorn were found. Some observations of desert bighorn sheep (*O. c. nelsoni*) in the White Mountains of California are included for comparative purposes.

METHODS

Most of the life history data were obtained by direct observation. The winter ranges were covered on foot to examine the vegetation, locate sheep sign, and search for sheep with the aid of 7x50 binoculars and a 15-to-60 variable-power spotting scope. Once spotted, sheep bands were usually observed for an extended period. Approximately 50 hours were spent watching activities.

[1] Submitted for publication, November 1965.

Samples of bighorn droppings were examined for the presence of lungworm (*Protostrongylus*) larvae. Samples of pellets were collected from dropping groups while still fresh and moist (nearly all were observed dropped) and placed in individual plastic bags to prevent drying until examination, which was usually performed the same evening. Collections were made at bedding sites or along individual tracks to avoid duplication of samples from the same animal.

However, from fecal analysis alone, it cannot be assumed that negative animals were completely uninfected. There are many inherent variables in the passing of the larvae, as pointed out by Forrester and Senger (1964). Other parasite eggs and larvae were routinely watched for.

Utilization of bitterbrush (this area lies in the transition between the two species *Purshia tridentata* and *P. glandulosa*) was determined on temporary $\frac{1}{13}$ acre belt transects (660 feet by 5 feet). Twenty plants representing all age and form classes were selected along the length of a transect and the number of grazed and ungrazed leaders was tallied for each plant. All parts of a plant within grazing height were sampled, 50 leaders per plant being set as a minimal goal. Large plants yielded much higher numbers while some small plants did not have 50 leaders, in which case as many as possible were tallied without repetition. The percent of twigs grazed was calculated for each plant, and the percent utilization on a transect was the mean of these values. Percent utilization as determined by this method is an index, rather than a measurement of total use, since no account is taken of the fact that on grazed leaders a portion of the base is often left uncropped. Pellet group counts were taken on all of the transects.

Utilization of desert needlegrass was determined along transects as described above. By clipping and weighing ungrazed *Stipa* bunches of various sizes, six categories of utilization were established: ungrazed, 1–20, 21–40, 41–60, 61–80, and 81–100 percent. Training was continued until these categories could be recognized visually. This task was simplified by the relatively uniform growth form and height in this species. Along each transect, *Stipa* bunches were recorded as ungrazed or grazed, and the amount of grazing estimated according to one of the above categories. An approximate percentage utilization was calculated by multiplying the midvalues of the six categories (ungrazed being zero) by the number of plants falling in each category, and dividing the sum of these values by the total plants tallied.

RESULTS

Bighorn Winter Ranges

The winter ranges defined by this study are given in Figure 1, where they are shown in relation to the summer ranges mapped from the descriptions of Jones (1950). The boundaries shown are by no means exclusive, but rather delineate major areas. In general, they agree with those given by Riegelhuth (1965).

The lower edges of the winter ranges are demarcated by the abrupt change in slope where the steep scarp, which forms the east slope of the Sierra, gives way to the lower alluvial plain on the west side of Owens Valley. In elevation, the lower edge reaches to about 5,000 feet

at the mouth of Sawmill Canyon while at George's Canyon it is highest at approximately 6,500 feet. The upper extent of the winter ranges is set by the fluctuating snow depth. In typical winters, the winter range would be covered one or more times by snow. However, these snows usually recede rapidly, particularly on the south-facing slopes, to an elevation where temperatures are more or less continuously below freezing, and a persistent snow cover is found throughout the winter. At Sawmill Canyon this zone is at about 7,500 feet and it ascends, with

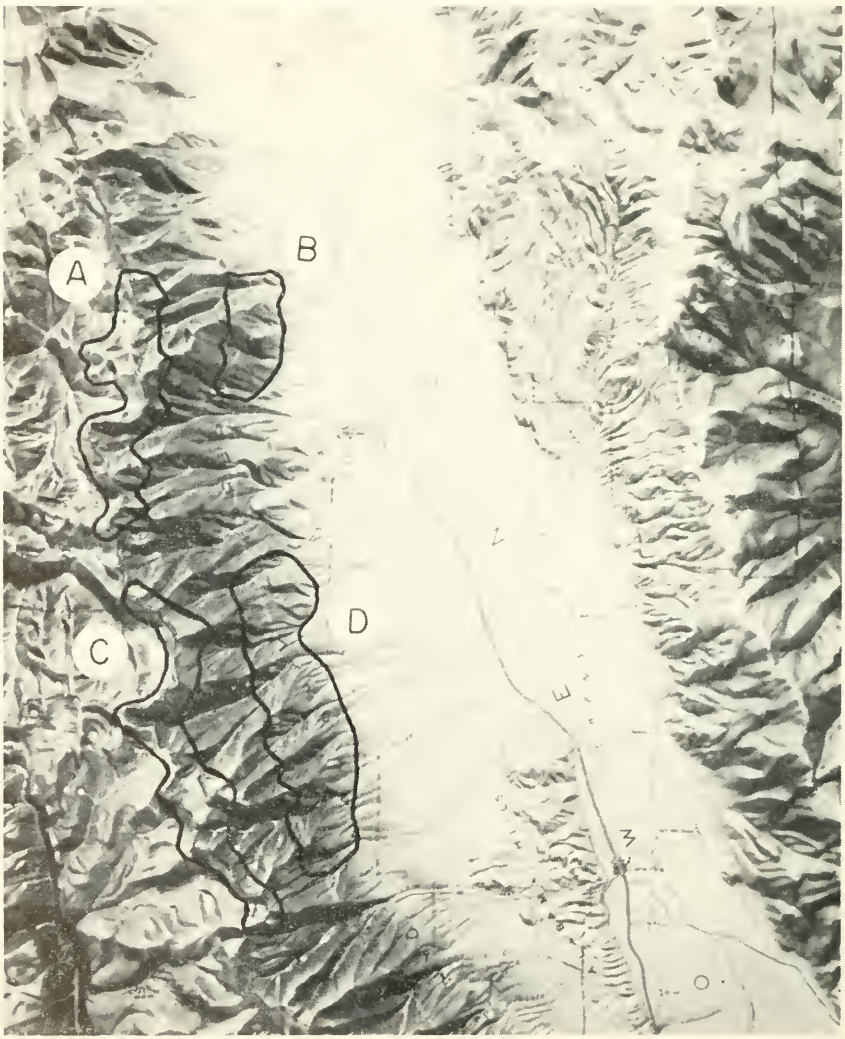

FIGURE 1. Ranges of the Mt. Baxter and Mt. Williamson bighorn sheep herds. Summer ranges mapped from the descriptions of Janes (1950). A. Summer range of the Mt. Baxter herd. B. Winter range of the Mt. Baxter herd. C. Summer range of the Mt. Williamson herd. D. Winter range of the Mt. Williamson herd. North is at the top of the picture. *Photograph by Edward R. Schneegas.*

the increasing temperatures to the southward, to approximately 8,500 feet at George's Canyon. Thus, in general terms, these limits establish an elevational zone of suitable wintering area of 2,000 to 2,500 feet.

The winter grounds are separated from the summer ranges along the crest of the Sierra by around 4,000 to 5,000 feet in elevation. However, distances are short due to the extreme slope—only about 3 miles for the Mt. Williamson herd where the winter range is directly below the summer range. For the Mt. Baxter herd, where the winter range lies at the northern end of the summer range, distances vary from 3 to about 7 miles. The area separating the winter and summer ranges can be considered to be intermediate range similar to that described for bighorn sheep in Idaho by Smith (1954).

Topography of Winter Range

Besides being extremely steep and rocky, several characteristics determine the suitability of an area for sheep winter range. First is the presence of a large exposed south- or southeast-facing slope. Sheep are sometimes found on north-facing slopes, but the vast majority are on slopes with good sun exposure. Two main types of terrain are present. The first consists of sheer, nearly bare rock faces which serve for escape and for limited feeding (Figure 2). Bighorns have a remarkable ability to traverse this terrain. The second type is less precipitous with loose, continuously eroding, decomposed granitic soils broken by granitic outcrops and strewn with large boulders (Figure 3). These areas are the primary feeding grounds. Canyons which show the greatest dispersion of these two terrain types support the largest bighorn populations.

FIGURE 2. A ram and ewe on a granitic slope in Sawmill Canyon, typical of the winter ranges. Sheep traverse this terrain effortlessly, and seldom venture far from it. *Photograph by Dale R. McCullough.*

Vegetation

The vegetation on the east slope of the Sierra Nevada has been described by DeDecker (1962) and the bighorn sheep range in particular by Jones (1950), Buechner (1960), and Riegelhuth (1965). The primary feeding grounds mentioned above support the *Eriogonum fasciculatum-Stipa speciosa* vegetation described by Buechner. Common associates on these decomposed granite soils include bitterbrush (*Purshia tridentata* or *glandulosa*), green ephedra (*Ephedra viridis*), big sagebrush (*Artemisia tridentata*), rabbitbrush (*Chrysothamnus viscidiflorus*), and low-growing perennial forbs (*Eriogonum* spp.). Common in rock outcroppings are *Haplopappus cuneatus* and *Penstemon breviflorus*. Grasses other than *Stipa* are squirreltail (*Sitanion Hystrix*), occasionally ricegrass (*Oryzopsis hymenoides*), and in good rainfall years redbrome (*Bromus rubens*) and cheatgrass (*Bromus tectorum*).

Composition of Bighorn Populations

One hundred eighty-two sightings of Sierra bighorn sheep were made in the study (Table 1). However, part of these were repeats, particularly in Black and Sawmill Canyons. Group size ranged from 1 to 18 with a mean of 7.6.

The observed sex ratio of 31 rams to 100 ewes is not reliable since the large rams remain segregated from the ewes for the most part, and occupy more inaccessible country. Also, the rams are considerably more wary than the ewes.

FIGURE 3. Two prime rams, two young rams, two ewes, and a lamb on a feeding ground on a bench just north of the mouth of Black Canyon. This is the gentlest terrain in which sheep were observed regularly. Note the escape terrain in the near background. *Photograph by Dale R. McCullough.*

The 1964–65 lamb to ewe ratio of 30:100 requires correction since non-breeding ewes are included in the ewe class. Yearling females were not classified in the study until we felt we were adequately trained in distinguishing this group, which is particularly difficult in Sierra sheep. Yearling females were much more easily distinguished among the desert bighorn in the White Mountains. Also, many groups were seen at distances too great to separate yearling females with assurance. However, based only on groups which were completely and positively classified, a yearling ewe to adult ewe ratio of 12:100 was obtained from a sample of 28 animals. This low ratio agreed with our general impression of a scarcity of yearlings, which was partly responsible for our reluctance to classify this age group until we were confident of doing so accurately. The low ratio is further substantiated by the fact that in the winter of 1963–64 the 13 ewes sighted were accompanied by only two lambs (15 lambs:100 ewes). While these results are based upon relatively small numbers, they indicate a poor lamb crop in 1963.

TABLE 1

Sierra Bighorn Sheep Sightings by Locality, Sex and Age

Locality and date	Ram	Ewe	Lamb	Unidentified	Total
Sawmill Canyon					
February 3, 1964				3	3
January 8, 1965				16	16
January 9, 1965	2	3			5
February 27, 1965	1	5	2		8
March 19, 1965	3	7	3		13
April 3, 1965	2	8	4		14
April 12, 1965		4			4
April 12, 1965	2	6	2		10
Black Canyon					
March 6, 1964	1	6	1		8
March 25, 1964		7	1		8
January 6, 1965	1	2			3
January 7, 1965	4	7	1		15
January 8, 1965	5	5	3	5	18
February 18, 1965	1	5	1		7
February 25, 1965	1	5	2		8
March 2, 1965	1	4			5
March 13, 1965	1	3	1		5
March 19, 1965		5			5
April 3, 1965	3				3
Thibaut Canyon					
March 16, 1965		7	2		9
Shepard Canyon					
January 13, 1965	1				1
Bairs Canyon (north fork)					
February 10, 1965		3			3
February 18, 1965	1	7	2		10
(near) George's Canyon					
February 19, 1965	1				1
Totals	**31**	**99**	**28**	**24**	**182**

Ratios	31:	100	:28
Winter of 1964–65 only			:30
Corrected for 12 percent yearlings			:34

When the 1964–65 winter ewe category is corrected for yearlings on the basis of the above yearling female to ewe ratio of 12:100, a corrected lamb to adult ewe ratio of 34:100 is obtained from a sample size of 102.

Movements

Although we saw too few individuals with recognizable natural marks to obtain any significant individual data beyond local movements, substantial shifts were detected on a population basis. Moderately heavy snows in January resulted in a concentration of sheep in the extremely steep canyons. Approximately 9 inches of snow lay on the level outside the mouths of Black and Sawmill Canyons. At this time, substantial numbers of large mature rams, which are usually widely scattered, were observed with the ewe groups. This snow receded rapidly with the coming of unseasonably warm weather during most of February and March. During this time the sheep dispersed, not only upward, but laterally where suitable habitat existed. Sheep were not found where they had been concentrated earlier. However, there was a slight resurgence of use of these areas following light snows in late March and early April, including the appearance of three large rams in Black Canyon.

Our observations were begun too late in the winter to obtain any information about the timing of the fall migration. Presumably heavy

TABLE 2

Winter Foods of Sierra Bighorn Sheep, and Their Relative Palatability and Availability. Arrangement and nomenclature from Munz and Keck (1963)

Species	Palatability	Availability
Pinyon, *Pinus monophylla*	Poor	Common at around 7,000 foot elevation
Green ephedra, *Ephedra viridis*	Excellent	Common and widespread
Nevada ephedra, *Ephedra nevadensis*	Good	Occasional in lower areas
California buckwheat, *Eriogonum fasciculatum*	Excellent	Common and widespread
Herbaceous buckwheat, *Eriogonum* spp.	Good	Common in areas
Manzanita, *Arctostaphylos patula*	Poor	Common in higher areas
Bush beardtongue, *Penstemon breviflorus*	Excellent	Common among jumbled boulders
Bitterbrush, *Purshia tridentata* and *glandulosa*	Excellent	Common and widespread
Curlleaf mountain mahogany, *Cercocarpus ledifolius*	Good	Common in higher areas
Desert Peach, *Prunus Andersonii*	Poor	Common and widespread
Willow, *Salix* spp.	Good	Occasional along streams
California coffeeberry, *Rhamnus californica*	Poor	Widespread but uncommon
Ceanothus, *Ceanothus Greggii*	Poor	Occasional in southern canyons
Elderberry, *Sambucus caerulea*	Good	Occasional
Wedgeleaf goldenbush, *Haplopappus cuneatus*	Good	Common in rocky cliffs
Big rabbitbrush, *Chrysothamnus nauseosus*	Poor	Common in disturbed areas (slides, etc.)
Rabbitbrush, *Chrysothamnus viscidiflorus*	Poor	Common and widespread
Sagebrush, *Artemisia tridentata*	Poor	Common in areas
Red brome, *Bromus rubens*	Fair	Common in good years
Cheatgrass, *Bromus tectorum*	Fair	Common in good years
Pine bluegrass, *Poa scabrella*	Good	Widespread but uncommon
Giant wildrye, *Elymus cinereus*	Fair	Occasional in southern canyons
Squirreltail, *Sitanion Hystrix*	Excellent	Widespread but uncommon
Indian ricegrass, *Oryzopsis hymenoides*	Excellent	Widespread but uncommon
Desert needlegrass, *Stipa speciosa*	Excellent	Common and widespread on south facing slopes
Large needlegrass, *Stipa coronata* var. *depauperata*	Poor	Occasional in southern canyons

snows are responsible for the migration. Our latest observation of sheep in the spring of 1965 was April 12.

Food Habits

Food data were obtained by direct observation of feeding animals. One grass *(Stipa)* and three shrubs (bitterbrush, California buckwheat, and green ephedra) composed the bulk of the diet (Table 2). In the early winter the sheep were taking about equal parts of each, with a small proportion of *Penstemon*, *Eriogonum*, *Haplopappus*, etc. Thus grasses did not comprise over 25 to 35 percent of the diet at that time. These results differ from those of most authors, who report a preponderance of grasses in the winter diet of bighorn sheep (Honess and Frost, 1942; Murie, 1944; Couey, 1950; Smith, 1954; Moser, 1962; Barrett, 1964; Yoakum, 1964). However, browse use to some degree was reported by these authors, and Welles and Welles (1961) felt browse was most important in the diet of the Death Valley sheep. Our observations of desert bighorns in the White Mountains showed grasses, mainly *Stipa speciosa* and *Hilaria Jamesii* are the most important food items.

Unusually early warm weather in late winter of 1965 brought on an early growth, and those plants which began growth earliest were readily taken. *Stipa speciosa* became the most important single item, accounting for 40 to 50 percent of the food. Consumption of California buckwheat and herbaceous *Eriogonum* increased, while use of green ephedra and bitterbrush dropped. Also, annuals began contributing to the diet. Heavy use of forbs has been reported in Arizona by Russo (1956), and many workers have found forbs to be commonly eaten when they are available.

Nutrient Value of Important Browse Species

The nutrient content of five important forage species was determined (Table 3). Samples were taken on February 16, 1965, on the gentler slopes lying just below the bighorn winter ranges on similar soils, and they are probably representative of the sheep area. Current growth was collected by hand to simulate observed grazing.

Crude protein for all of the browse species was well above the 5 percent level which Einarsen (1946) considered minimal for deer, and around the 7.6 percent recommended as minimum for early pregnancy in domestic sheep ewes by the National Research Council (1957) (Table 3). *Stipa* was low in crude protein, as is typical of dry grasses.

TABLE 3

Nutritive Dry Weight Composition of Important Bighorn Sheep Winter Forage Plants in Percent

Species	Protein	Ash	Fat	Fiber	NFE	Ca	P	Ca–P ratio
Stipa speciosa	4.2	7.4	2.3	31.6	54.5	.28	.04	7.0
Purshia spp.	9.1	4.5	7.0	24.1	55.3	1.14	.11	10.4
Eriogonum fasciculatum	6.1	4.6	2.5	12.1	74.7	1.49	.14	10.7
Haplopappus cuneatus	6.6	7.0	17.0	13.8	55.6	1.42	.09	15.8
Ephedra viridis	8.8	9.7	4.1	22.2	54.9	3.25	.09	36.1

The easily metabolizeable fats and nitrogen-free-extract (NFE), the basic energy-producing components, were quite high in all species. California buckwheat was particularly high in NFE, and it probably contributes substantial amounts of energy to the diet. *Haplopappus* contains high fat quantities, but much of this is in the form of essential oils in this highly aromatic species, and typically, they are lost through the urine. Fiber, which is poorly digested, was relatively low in all of the species tested.

Ash content is quite high for winter samples. Calcium in particular is well above the minimum levels (0.20-0.27 percent) recommended for domestic sheep by the National Research Council (1957). However phosphorus in all species is very low. The National Research Council gives a minimum level of 0.16 percent for heavy domestic ewes in early pregnancy. The highest level obtained in the species tested was 0.14 percent for California buckwheat. Furthermore, the calcium to phosphorus ratios are well above the 2:1 ratio given by Maynard and Loosli (1956) as the best for utilization of these minerals. With a large excess of calcium, phosphorus tends to be tied up as insoluble tricalcium phosphate, and thus cannot be absorbed. The calcium-phosphorus ratios shown in Table 3 are so unbalanced that interference with the absorption of the already limited phosphorus probably occurs.

Parasites

Jones (1950) reported that examination of 12 fecal samples collected on the summer range gave no evidence of parasites. The results of lungworm (*Protostrongylus*) examination of 40 fecal samples collected from four different Sierra bighorn canyons in this study are presented in Table 4. Ten samples collected in Lone Tree Canyon in the White Mountains from desert bighorn are included for comparison.

Samples from all areas showed the presence of lungworms. Compared to the White Mountain sheep, the Sierra sheep have a relatively low level of infection. Only 42.5 percent of the Sierra samples were positive as compared to 89 percent for the samples from the Whites. Sample size from the Whites was small, but the results are correlated with the number of larvae per fecal pellet between the two populations. The highest number of larvae per pellet obtained from Sierra populations

TABLE 4

Results of Fecal Examinations for Lungworm Larvae

Locality	Sample size	Negative	Positive	Percent positive
White Mountains				
Lone Tree Canyon	10	2	8	80
	10	2	8	80
Sierra Nevada				
Sawmill Canyon	12	7	5	42
Black Canyon	10	5	5	50
Thibaut Canyon	14	10	4	29
Bairs Canyon	4	1	3	75
	40	23	17	$\bar{X}$ = 42.5

was 10, while several samples from the Whites showed over 100 per pellet. Further evidence came from field observations. Individuals in the White Mountains had chronic coughs; running noses and rough, dull pelage were the rule. The Sierra sheep were generally sleek and no coughing was heard, despite the much greater time spent observing these sheep.

Three genera of land snails which may serve as intermediate hosts for lungworm larvae were found in Black Canyon. Two, *Euconulus* and *Vallonia*, were found capable of serving as intermediate hosts by Donald J. Forrester in Montana (letter dated April 2, 1965). The third, *Discus*, has not yet been implicated.

Nine of the Sierra sheep pellet samples examined were from lambs, and all were negative for lungworm. However, seven of the nine lamb samples contained eggs of *Nematodirus* sp., a strongylid which lives in the duodenum. The frequency with which these eggs were encountered using a technique that does not selectively concentrate them suggests relative abundance of this parasite. Only one fecal sample from an adult contained this parasite; a single ova was found in one of the White Mountain samples. *Nematodirus* was reported in bighorn sheep by Honess and Winter (1956) and Forrester and Hoffmann (1963).

Ranges of Other Grazing Animals

The distribution of other grazing animals in relation to bighorn sheep ranges is of concern since Jones (1950) postulated that competition from deer (*Odocoileus hemionus ingoensis*) and domestic livestock might be partially responsible for the historical decline of Sierra bighorn sheep, and that they posed a continuing threat to bighorn populations.

Deer and bighorn winter ranges show a remarkable separation on the eastern Sierra from Whitney Portal to Taboose Canyon. Two major deer winter ranges occur in this area: the Goodale-Division Creek herd and the Oak Creek herd. The former lies to the north of the Mt. Baxter bighorn winter range, while the latter lies in the gap between the Baxter and Williamson sheep winter ranges. As pointed out by Jones (1954), deer summer range is essentially absent east of the Sierra crest in the Owens Valley area. Thus locations of major deer winter ranges are dictated by the presence of suitable passes to allow access to the summer ranges on the west slopes of the Sierra. Taboose Pass serves the Division-Goodale deer herd, while Kearsarge Pass serves the Oak Creek herd. The area between Taboose and Kearsarge Passes, which comprises the Baxter sheep herd summer range, is generally unsuitable for deer passage and the crest from Kearsarge south along the Williamson sheep range forms a formidable barrier.

Nevertheless, low numbers of deer do occur in the vicinity of the sheep winter ranges but here too, there is a strong separation between the two species. Deer occupy mainly the dense bitterbrush stands lying on the alluvial fans below the sheep canyons. Also, deer are commonly found on the north-facing slopes on the opposite side of the ridges from the important sheep winter ranges. Thus we have actually observed on north slopes opposite major sheep ranges 5 deer at Thibaut Canyon, 11 at Black Canyon, and 17 at Sawmill Canyon. On the north slope of Taboose, a canyon of questionable sheep status, we saw five deer. Fresh

deer tracks in these areas are the rule rather than the exception. There is no question that deer do occur within the prime bighorn range occasionally. We found an old cast antler in Sawmill Canyon and two others in Black Canyon, and one deer was seen in the east-facing rocky outcropping of Black Canyon which is a contiguous part of that sheep range. Vern Burandt of the California Department of Fish and Game has reported (Pers. Comm.) finding sheep and deer almost together in this same area.

The tule elk (*Cervus nannodes*) was introduced into Owens Valley in 1933, and is now well established. Elk use the area along the foot of the Mt. Baxter sheep winter ranges for approximately 3 to 4 months in the winter and early spring. The Williamson sheep herd winter range area is not used by elk. Although the more gradual slopes up to approximately the timberline are utilized by elk, there is no question that the preponderance of elk use lies below the bighorn ranges, superimposed on deer use. Elk are even less adapted physically to penetrate the bighorn range than deer. Hence, only the edges of the deer and elk ranges overlap those of the bighorn, and use of these marginal areas by both deer and elk is sporadic.

The last grazing allotment for domestic sheep on the Inyo National Forest lands adjacent to bighorn ranges was closed in 1961. Sheep grazing had been light for a number of years prior to final closure, and had been regulated to take primarily early spring forb growth. Also, domestic cattle grazing was eliminated at the end of the 1965 season on National Forest lands between Taboose Creek and Thibaut Creek. This extent covers nearly all of the winter range of the Baxter herd. Moderate cattle grazing is permitted below George's Canyon of the Williamson bighorn herd winter range. On the George's Creek allotment, which is fenced, 89 head of cattle are allowed from July 7 through September 30 for a total of approximately 267 animal unit months. The Independence allotment falls in the gap between the two sheep ranges. It consists of 40 head of cows from June 16 through September 30 resulting in about 140 animal unit months of use.

Range Utilization

Bitterbrush is the single most important browse species present, and we have used it as a key species to reflect the impact of grazing animals upon the predominantly shrubby vegetation on these ranges. Utilization measurements were taken on transects in every major bitterbrush stand at the foot of the steep slopes below bighorn range from Sawmill to Thibaut Canyon (transects S-1 through S-7, Table 5). The dropping counts indicate the relative use of the area by deer, elk, and cattle. Another transect (S-8, Table 5) was taken on top of the bench on the north ridge just at the mouth of Black Canyon in a favorite bighorn sheep feeding area (Figure 3). Although the droppings of deer and bighorn sheep cannot be reliably distinguished, the tracks can be, and the separation of the species between these two areas, the most closely observed in the study, was complete.

Only the 1964 season's growth of leaders was included in the tallies which were taken May 25 and 26, 1965. Growth was relatively poor during 1964, a drought year. Average leader length was approximately 1.4 inches.

The utilization of bitterbrush on the bighorn sheep area, 22.5 percent (Table 5), was substantially greater than that on the lower stands used by deer, elk, and cattle (average of 6 percent). The number of bighorn sheep droppings substantiates our visual observations that transect S-8 was in an important sheep feeding area, typical of the major feeding places described earlier. Deer use on the lower ranges, indicated by pellet counts, was quite low, and while elk and cattle sign was common, the bulk of their forage came from grasses and forbs as shown below in the case of *Stipa*. In neither area did bitterbrush utilization approach the 60 percent considered by Hormay (1943) to be the maximum consistent with maintenance of stand vigor.

Desert needlegrass is by far the most abundant grass, and it occurs principally on south-facing slopes, which are favored by sheep as winter ranges. Although other grass species, as for example Indian ricegrass, are more palatable, they are quite sparse. Consequently *Stipa* constitutes the major portion of grasses in the diet of bighorns as well as elk and cattle.

To study the relationship of grass use by these forms, a series of horizontal *Stipa* utilization transects was established at approximately 115-foot elevational intervals up the shallow draw on the east slope of Sand Mountain (Lookout Point) located between Sawmill and Black Canyons. The lowest transect was on the low edge of the *Stipa* stand, and the highest near the upper edge. Bitterbrush stands are present at the lowest *Stipa* transects, and bitterbrush utilization transects S-3 and S-4 (Table 5) were one on either side of this area. Only a few scattered bitterbrush plants occur above 5,200 feet elevation in this locality. Utilization by elk and cattle, based on sign and field observations, was heavily concentrated at the lower more gentle slopes. Deer use the entire slope but most heavily at the lower edge where bitterbrush is common. Use by bighorn sheep occurs just below the upper edge of the *Stipa* stand where an adjacent rocky outcrop affords a suitable travel lane and escape cover.

It is apparent that elk and cattle had the heaviest impact on the lower, gentler slopes. This impact decreased rapidly with increasing

TABLE 5

Summary of Bitterbrush Utilization and Pellet Group Counts on Belt Transects

Transect area	Percent utilization of bitterbrush	Pellet groups			
		Deer	Elk	Cattle	Bighorn
S-1 Sawmill Canyon	11.7	2	11	2	--
S-2 Sawmill Canyon	8.7	9	14	7	--
S-3 Sand Mountain	5.8	0	17	8	--
S-4 Sand Mountain	8.1	0	20	7	--
S-5 Grover Anton	1.0	1	2	4	--
S-6 Grover Anton	1.5	4	3	2	--
S-7 Black Canyon	2.3	2	2	5	--
Means	6.0	3	10	5	--
S-8 Black Canyon	22.5	--	--	--	11

elevation, and utilization dropped to nearly zero except in the area of bighorn sheep use (Figure 4). In the bighorn area, less than 10 percent of the *Stipa* bunches were grazed, and almost without exception, only the very tips of the leaves had been cropped. *Stipa* utilization was measured on the bighorn sheep transect (S-8, Table 5) at Black Canyon, where 26 percent of the bunches were grazed, and estimations gave 3 percent utilization. The heavier use of the Black Canyon area agrees with our field observations that this is a much more important bighorn feeding area.

Thus, utilization of *Stipa* on bighorn ranges is light, and there is a buffer zone where utilization is nil between them and deer-elk-cattle ranges. Even in the area of heaviest elk and cattle use utilization does not seem to be excessive at present.

DISCUSSION

Population Status

From the data at hand, we do not feel any meaningful estimate of actual bighorn numbers can be made. As concerns status, we believe the herds studied are in satisfactory condition at present. The frequency with which we located sheep bands whenever adequate physical exertion was made attests to the fair numbers present on the range. Part of the impression of rareness is related to the infrequency with

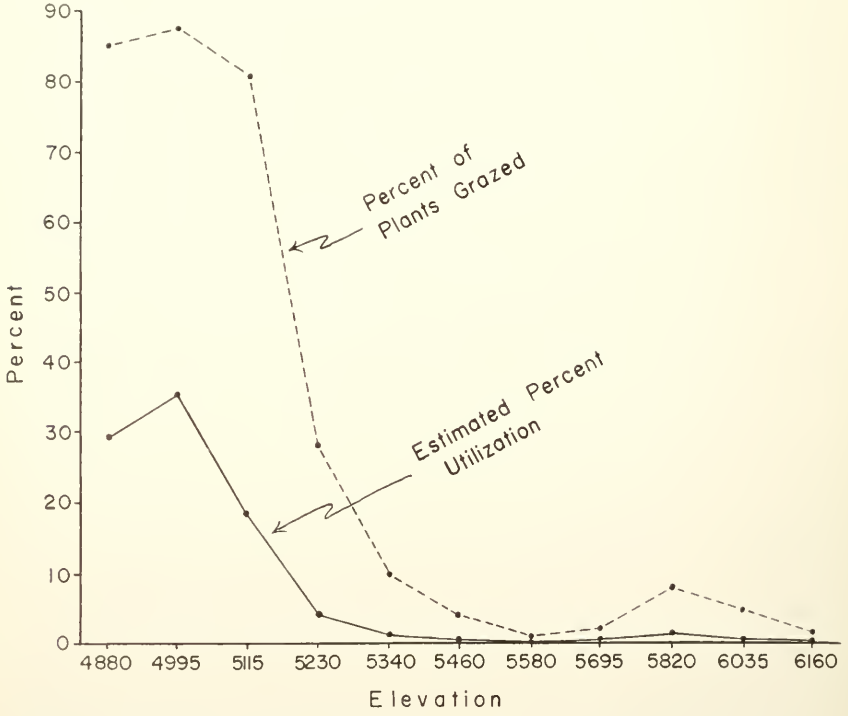

FIGURE 4. Utilization of *Stipa speciasa* along a series of horizontal transects located at intervals of approximately 115 feet elevation on the east slope of Sand Mountain.

which people enter these formidable canyons. Only a handful of local people have ever seen a Sierra bighorn, and the majority do not even know they exist.

Yet the moderate utilization of the forage resources by sheep shows that the population is not out of balance with range capacity. Although in the winter of 1964–65 the early emergence of annual growth relieved the pressure on the range, it seems unlikely that there would have been a food shortage even without this fortunate circumstance, and this was the production of a drought season.

Population Trend

The absence of long-term records makes it difficult to assess population trend. The lamb-ewe ratio of 34:100 for the 1964–65 winter would seem to be relatively low, and of the same order as those reported by Woodgerd (1964) in the leveling-off of the Wildhorse Island sheep herd in Montana. Limited evidence points to very poor recruitment in the previous season which, incidentally, was a high rainfall year. Taking into account these ratios, range analysis, and the reports of a few informed local residents, we believe the recent trend has been more or less static.

Controlling Factors

As regards food, the generally satisfactory condition of the winter range in conjunction with low utilization of key species argues against direct population regulation by starvation. Further evidence is that lamb production was higher in the drought year than in the good year during the study. Values of nutrients in the important winter species, with the exception of phosphorus, seem to be satisfactory, but whether there is correspondingly good digestibility by sheep is not known.

The particularly low levels of phosphorus are suggestive that this factor may have an important bearing on population dynamics. Phosphorus deficiency can result in subtle changes in reproductive rate, lower metabolic efficiency, etc., so that its role in population regulation is difficult to assess. Although the plant species tested are some of the most important foods, phosphorus is required in low enough amounts that it might be furnished adequately by minor forage plants containing high levels.

There is nearly no use-overlap of present bighorn range by other grazing species, so interspecific forage competition is now nearly nonexistent. Because of the basic differences in physical adaptations and habitat selection, it seems extremely unlikely that deer, elk, or cattle will ever make significant inroads into the heart of bighorn territory. At present there is heavier use of bitterbrush on the bighorn ranges than on the deer-elk-cattle ranges below.

While today the sheep rarely venture onto the lower slopes, the possibility that they may have done so routinely in pristine times cannot be ruled out. The activities of man or the presence of domestic stock could have influenced the behavior of the bighorn; behavioral incompatibility with domestic stock might have caused sheep to abandon the lower slopes. However, there is no solid evidence that bighorn formerly used these areas any more than at present.

It was Jones's (1950) belief, repeated by Buechner (1960) that greatest competition between bighorn and deer occurs during hard winters when extremely heavy snows drive the sheep out of the canyons onto the deer range below. At present the light utilization of bitterbrush on the lower slope would seem to allow a sufficient reserve of forage. Such may not always have been the case in the past; as pointed out by Riegelhuth (1965), deer are now at the lowest number they have been for many years. However, the sheep canyons are removed from the major deer winter ranges, and there is question if over-use occurred even during high deer populations.

This aside, we find several difficulties with the hypothesis. First, whether or not the sheep actually are driven out of the canyons still requires substantiation. The historic records are few and vague about the level to which sheep descend. Our observations in moderate snow show that rather than moving out, sheep tend to concentrate in the canyons where the steep slopes and persistent canyon winds prevent deep accumulation. Whether this is also true under heavy snow conditions is unknown. But assuming the bighorn are indeed driven from the narrow canyons, several logical discrepancies arise.

Appreciable snows in this region are invariably general over Owens Valley, and although there is usually a north to south decline in amount, snow depth at any particular latitude depends mainly upon the elevational gradient in temperature, which results in melting at the lower levels. Since the bitterbrush zone encompasses only about 300 to 400 feet elevation below the canyon mouths, there is little difference in snow depth between the two areas in any reasonably heavy snowfall. We have verified this fact three times in the last two winters with snowfalls of 6 to 10 inches. To obtain a substantial decrease in the depth of snow would require a long move down these gentler alluvial fans, which would soon put the sheep well below the bitterbrush zone, the area where over-utilization of the range by deer, cattle, or elk might occur. And if they don't escape the deep snow, we have difficulty seeing the advantages of moving from the relative safety of the canyons to the area immediately below, where they would still have to contend with snow and would be removed from the escape area afforded by the rocky cliffs.

Certainly, heavy snows impose a severe strain on the sheep: high energy requirement to move about, danger of foundering, increased susceptibility to predators, less available food, etc. These factors probably increase mortality irrespective of how the sheep behave. The final analysis of these factors in relation to interspecific forage competition must await careful observation made during a hard winter.

The role of disease in the population is another unanswered question. While at present the low level of lungworm infestation seems to be causing little difficulty, it is conceivable that periodic outbreaks could drastically reduce the herd as has happened in other areas (Buechner, 1960).

Particularly intriguing is the apparent heavy infestation of *Nematodirus* in lambs. This finding could have great implications in survival of lambs through their first year.

Finally, the largest sheep herds are those with the best winter ranges in terms of a balance between the necessary habitat components.

Sawmill and Black Canyons are prime examples of the ideal winter range, and this may have a direct tie to the large size of the Mt. Baxter herd. The second best winter area is in the Bairs Creek-North Fork of Bairs Creek vicinity, which serves the substantial Mt. Williamson herd. We have visited potential winter ranges of the other three herds described by Jones (1950), and found them lacking in one or more respects, particularly in suitable terrain.

That there was a marked decline in numbers due to the drastic reduction of the original range with the coming of white men of European stock is abundantly documented by Jones (1950), and probably there was a related decline within the areas where sheep persisted. But it may be time to question the prevalent notion that Sierra sheep are still at a population below the capacity of the present range.

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Our indebtedness for all of these services is gratefully acknowledged.

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SUMMARY

Studies of the winter ranges of the Mt. Baxter and Mt. Williamson herds of Sierra bighorn sheep (*Ovis canadensis californiana*) were conducted in the winters of 1963–64 and 1964–65. Winter ranges were characterized by extremely steep and rocky granitic cliffs interspersed with decomposed granite gravel slopes with good sun exposure. The former serve for escape while the latter are the primary feeding areas. One hundred eight-two bighorns were sighted. A corrected lamb-to-ewe ratio of 34:100 was obtained for the winter of 1964–65. Limited evidence points to an even lower ratio for the previous winter. Moderate snows concentrated the sheep in the canyons, while snow-free periods resulted in dispersal. Most of the winter diet is composed of browse, particularly bitterbrush, California buckwheat, and green ephedra. Desert needlegrass was also important. Nutritional properties of the important forage species were quite high except in phosphorus. Phosphorus was deficient and its availability complicated by unbalanced calcium-phosphorus ratios. The Sierra sheep harbored moderate infestations of lungworm (*Protostrongylus*). Lambs were lightly infected by lungworms, but showed heavy parasitism by *Nematodirus*. Ranges of deer, tule elk, and domestic cattle barely overlapped the bighorn sheep ranges.

Utilization of bitterbrush was heavier on bighorn range while desert needlegrass was more heavily used on deer-elk-cattle ranges. Neither

area showed excessive range use. Most of the evidence suggests a more or less static sheep population. The availability of suitable terrain, quantity and quality of forage, parasites and interspecific competition are discussed as possible population control factors.

LITERATURE CITED

Barrett, Reginald H. 1961. Seasonal food habits of the bighorn at the Desert Game Range, Nevada. Trans. Desert Bighorn Council 8: 85-93, Mimeo.

Buechner, Helmut K. 1960. The bighorn sheep in the United States, its past, present, and future. Wildl. Monogr., (4): 1–174.

Couey, Faye M. 1950. Rocky Mountain bighorn sheep of Montana. Montana Fish and Game Comm., Bull., (2): 1–90.

DeDecker, Mary. 1962. Plants. Pages 123–148. In: Genny Schumacher (Editor), Deepest valley. Sierra Club, San Francisco, 206 pp.

Einarsen, Arthur S. 1946. Crude protein determination of deer food as an applied management technique. Trans. N. Am. Wildl. Conf., 11: 309–312.

Forrester, Donald J., and Robert S. Hoffmann. 1963. Growth and behavior of a captive bighorn lamb. Jour. Mamm., 44(1): 116–118.

Forrester, Donald J., and Clyde M. Senger. 1964. A survey of lungworm infection in bighorn sheep of Montana. Jour. Wildl. Mgmt., 28(3): 481–491.

Honess, Ralph F., and Nedward M. Frost. 1942. A Wyoming bighorn sheep study. Wyoming Game and Fish Dept., Bull., (1): 1–127.

Honess, Ralph F., and Kenneth B. Winter. 1956. Diseases of wildlife in Wyoming. Wyoming Game and Fish Dept., Bull., (9): 1–279.

Hormay, August L. 1943. Bitterbrush in California. U.S. Dept. Agric., Forest Service, California Forest and Range Exp. Sta., Note, (34): 1-13.

Jones, Fred L. 1950. A survey of the Sierra Nevada bighorn. Sierra Club Bull., 35(6): 29–76.

——— 1954. The Inyo-Sierra deer herds. California Dept. Fish and Game. Fed. Aid Proj. W-41-R., Rept., 84 p. Mimeo.

Maynard, Leonard A., and John K. Loosli. 1956. Animal nutrition. 5th ed. McGraw Hill Co. Inc., New York, 533 p.

Moser, Clifford A. 1962. The bighorn sheep of Colorado. Colorado Fish and Game Dept., Tech. Publ., (10): 1–49.

Munz, Philip A., and David D. Keck. 1963. A California flora. University of California Press, Berkeley and Los Angeles. 1681 p.

Murie, Adolph. 1944. The wolves of Mount McKinley. U.S. National Park Serv., Fauna Ser., (5): 1–238.

National Research Council. 1957. Nutritional requirements of domestic animals: nutrient requirements of sheep. Natl. Res. Council, Wash., D.C., Leaflet, (5): 1–33.

Riegelhuth, Richard. 1965. A reconnaissance of Sierra bighorn and bighorn ranges in the Sierra Nevada. Trans. Desert Bighorn Council, 9: (in press). Mimeo.

Russo, John P. 1956. The desert bighorn sheep in Arizona. Arizona Game and Fish Dept., Fed. Aid Proj. W-55-R, Rept., 153 p.

Smith, Dwight R. 1954. The bighorn sheep in Idaho. Idaho Dept. of Fish and Game, Wildl. Bull., (1): 1–154.

Welles, Ralph E., and Florence B. Welles. 1961. The bighorn of Death Valley. U.S. National Park Service, Fauna Ser., (6): 1–242.

Woodgerd, Wesley. 1964. Population dynamics of bighorn sheep on Wildhorse Island. Jour. Wildl. Mgmt., 28(2): 381–391.

Yoakum, James D. 1964. Bighorn food habit—range relationship in the Silver Peak Range, Nevada. Trans. Desert Bighorn Council, 8: 95–102, Mimeo.

Calif. Fish and Game, 52(2) : 85–91. 1966.

AN EARLY HEPATOMA EPIZOOTIC IN RAINBOW TROUT, *SALMO GAIRDNERII*[1][2]

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Two epizootics of rainbow trout hepatoma have occured in California State trout hatcheries in the past 30 years. The first occured during the period 1936–42 and the second during 1950–60. Both appear to have been closely associated with the introduction of certain dry plant and animal meals into the diet. Analysis of records for the 1936–42 epizootic plus more recent findings indicate that fish meal or cottonseed meal contained the cercinogen. Chlorinated pesticides and fungicides and solvent residues could not be implicated in the 1936–42 epizootic. Other environmental factors were considered, but these appear to be of negative or indirect impartance.

INTRODUCTION

Two cases of rainbow trout hepatoma have occurred in epizootic proportions in California trout hatcheries within the past 30 years. The most notable occurrence attracted widespread attention in 1960. Less well known is an earlier epizootic that occurred during 1936–42. Wales recently reviewed all records of this earlier outbreak as a basis for this paper (Table 1). Our purpose in writing this is to document the earlier epizootic and draw conclusions from possible causes.

We are indebted to the following persons for review of hepatoma sections made by Wales during the period 1937–40: Raymond Bangle, Jr., M.D., Cancer Detection Center, Los Angeles; Hugh Edmundson, M.D., Head of Department of Pathology, University of Southern California School of Medicine, Los Angeles; Ross F. Nigrelli, Pathologist, New York Aquarium; R. R. Rucker and W. T. Yasutake, Fish Pathologists, U.S. Bureau of Sport Fisheries and Wildlife, Seattle, Washington; Harold Wolf, Fisheries Pathologist, California Department of Fish and Game, Sacramento, California; Edward M. Wood, M.D., Pathologist, Tacoma General Hospital, Tacoma, Washington. We are also deeply grateful for the assistance of the California Department of Fish and Game, by whom Wales was employed as parasitologist from 1932 to 1959.

BACKGROUND

Insofar as is known, rainbow trout are far more susceptible to hepatoma than are other species of domestically-reared fishes. From 6 months in warmer waters to 2 years in colder waters are required for hepatoma to become easily recognized. Before World War II, only two trout hatcheries in California maintained brood stocks of rainbow trout

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reaching an age at which hepatoma might be detected. Before 1933, some of the sources of rainbow trout eggs for the California hatcheries included wild, migratory rainbow (steelhead) of Pacific coastal streams. It has not been demonstrated whether these wild, migratory fish are as susceptible to hepatoma as their domesticated relatives.

In the fall of 1933, a shipment of eggs was received at Hot Creek Hatchery, California, from the U.S. Fish and Wildlife Service hatchery at Springville, Utah. Before this, the brood stock had been held at Bourbon, Missouri. The stock had been domesticated for a little more than 50 years and, although not selected to the extent of producing an inbred strain, its growth rate had been developed until it may have been twice that of the wild trout from which it originated.

CHRONOLOGY

Hot Creek Hatchery

The trout diet at Hot Creek Hatchery has been changed many times in the past 32 years. The most commonly used foods have been slaughterhouse by-products such as beef liver, hearts, and lungs, horse meat, and fresh ocean fish. It is important that these have been fresh products and not dry meals. In addition to these fresh meats and fish, a number of dry meals were used at different times, and it is with these that we are most concerned.

We presume that the Hot Creek Hatchery diet in 1933 and 1934 contained no dry meals; but by 1935, feeding experiments of Wales indicated the value of using certain meals, and we know that the diet at Hot Creek in 1935 was 30 percent beef liver, 35 percent salmon egg meal, and 35 percent abalone meal (Wales and Lewis, 1935). The 1936 hatchery records show that meals of cottonseed, salmon egg, abalone, and meat were used in conjunction with fresh beef liver. The hatchery

TABLE 1

Chronology of Events Pertinent to the Two Epizootics of Hepatoma in California Trout Hatcheries

Year	Hot Creek Hatchery	Mt. Shasta Hatchery
1933	Eggs of selected, fall-spawning rainbow trout received from Missouri.	
1934	Hatchery diet contained no dry meals.	
1935	Various dry meals (wheat middlings, salmon meal, abalone meal) added to fresh meat diet.	
1936	Cottonseed meal added to diet.	Wheat middlings, salmon egg meal, abalone meal, dry milk, cottonseed meal, added to fresh meat.
1937	Hepatoma first noted at this hatchery.	Fingerling rainbow transferred to this hatchery from Hot Creek to form a new brood stock.
1939	Dry meals discontinued.	Hepatoma first noted at this hatchery.
1942	Hepatoma no longer a serious problem.	Hepatoma no longer a serious problem.
	Statewide	
1944	Chlorinated insecticides began to replace pyrethrum and arsenic in household and crop sprays.	
1947	Solvent process began to replace expeller process in cottonseed oil extraction.	
1958	Dry meal pellets being widely used in all hatcheries.	
1960	Second epizootic of hepatoma widely distributed in all hatcheries.	
1962	Hepatoma no longer a serious hatchery problem, presumably due to diet modification.	

received cottonseed meal in January, so this could have been used throughout 1936. In November 1937, yearling and adult rainbow were fed liver 2 days a week and pellets the remaining 5. These pellets consisted of $\frac{1}{3}$ abalone meal, $\frac{1}{3}$ cottonseed meal, and $\frac{1}{3}$ salmon egg meal, plus some watercress for moisture. However, due to the extremely poor fertility of brown trout eggs at Mt. Shasta Hatchery, California, in the fall of 1937, cottonseed meal was replaced by wheat middlings at both Mt. Shasta and Hot Creek hatcheries. For some time after this, the Hot Creek fish were fed pellets made of salmon egg meal, middlings, dried skim milk, and watercress.

Sometime during the summer or fall of 1936, H. S. Davis, in charge, Aquicultural Investigations, U.S. Bureau of Fisheries, visited Hot Creek Hatchery. He found furunculosis and another disorder, which he could not identify, in the rainbow brood stock. This latter disorder was called to Wales's attention about January 1, 1937 by the hatchery superintendent, R. C. Lewis. Liver tissue was sent to the Rockefeller Institute of New York City during the winter of 1937–38, and the disorder was reported to be a type of cancer, but apparently nothing was published on the subject. We now assume that hepatoma was present in the summer or fall of 1936 when Davis visited the hatchery. From studies made in recent years, we know that in water of 56° F. the minimum developmental time for hepatoma is about 6 to 8 months (Harold Wolf, pers. comm.). Because hepatoma, as such, was not known to exist in trout anywhere in North America in 1936, we assume that tumors would have to have been rather well advanced to have been noticed. Recent studies have shown diets to be carcinogenic without containing salmon egg meal, abalone meal, or fresh ocean fish (Wolf and Jackson, 1963). Thus, we believe that the carcinogen could have been in the wheat middlings, or in the cottonseed meal.

The incidence of hepatoma at Hot Creek is known to have been high, but apparently no attempt was made to determine its extent in anything but dead fish. During October 1937, at what may have been the peak of the epizootic, 30 out of 315 female brood stock and 6 of 226 males died. Upon dissection, all of the dead fish contained hepatoma. The hatchery records reveal that females usually suffered more heavily from hepatoma than males.

Mt. Shasta Hatchery

In April 1937, offspring of the original fall-spawning rainbow brood stock were transported from Hot Creek Hatchery to Mt. Shasta Hatchery to establish a second brood stock. These fish were 5 months old at the time. The water temperature at Mt. Shasta averaged about 48° F. in contrast to 56° F. at Hot Creek, and the water chemistry of the two stations was also quite dissimilar. This is emphasized because the high boron and fluoride content of Hot Creek water and its relatively high temperature were suspected to be conducive to hepatoma and furunculosis. The fingerling (subyearling) rainbow taken to Mt. Shasta Hatchery were fed the customary diet of slaughterhouse by-products until they were approximately 1 year old. About this time, they were usually placed in ponds and fed a meal-meat mixture. In January 1936, a diet of cooked wheat middlings, cottonseed meal, salmon egg meal, and fresh ocean fish was tested on part of the brown trout brood

stock. This diet may have been used for the yearling and 2-year-old rainbow from late 1937 through 1938 and 1939. In December 1937, after cottonseed meal was held responsible for lowered brown trout egg viability, this ingredient was removed from the diet of the brood fish. Cottonseed meal also was impossible to feed through the feeding dipper used for the subyearling trout because of its large hull particles. The other meals which might have been fed to yearling and 2-year-old rainbow at Mt. Shasta were wheat middlings, salmon egg, dry skim milk, abalone, and kelp.

In November 1939, when the oldest rainbow brood fish at Mt. Shasta were 3 years old, Wales found hepatoma in them. At an average temperature of 49° F., hepatoma requires about 2 years to develop easily recognizable tumors. Therefore, these rainbow must have been subjected to some carcinogen starting about November 1937. This means that within 6 months of the time they reached Mt. Shasta from Hot Creek they had been subjected to the carcinogen. These fish had received nothing but beef liver or heart at Hot Creek during the first 5 months of their lives, and it was customary at Mt. Shasta to feed young fish a fresh meat diet until they were approximately 1 year old. Therefore, we assume that they began getting something besides fresh meat about November 1937, and that this contained a carcinogen which in 2 years produced the tumors found in November 1939. In 1936, cottonseed meal, salmon egg meal, dry skim milk, and abalone meal could have been in use. It seems reasonable to suspect that the carcinogen might have been in the cottonseed meal (expeller or hydraulic process) simply by eliminating the other components. Recent tests have shown a low incidence of hepatoma in fish fed wheat middlings (Wolf and Jackson, 1963). However, to our knowledge, no tests incriminating dry skim milk, abalone meal, or salmon egg meal have been made.

These records show that the Department of Fish and Game was becoming concerned with dry meals as trout food. Some meals were recognized as safe to use and were economical in feeding hatchery trout, but much of the earlier enthusiasm had been lost. This was particularly true of their use for brood trout. The quality of the eggs appeared to be appreciably poorer when brood trout were fed diets high in meal. In addition, the department recognized that diet might be implicated in the hepatoma problem. Therefore, in the early 1940's, the use of meals decreased, especially in the rainbow trout being held for brood stock. As the rainbow trout brood fish with hepatoma died at the two affected hatcheries, the low-meal or mealless diets failed to reproduce the neoplasm and for a number of years hepatoma was not observed in California.

In the mid-1950's, hatcheries in many parts of the United States began to use dry meal pellets made by commercial animal food manufacturers, especially for trout. By 1960 the incidence of hepatoma was high enough to trigger nationwide publicity (Hueper and Payne, 1961).

The possibility that salmon egg meal, cottonseed meal, or wheat middlings might have contained the carcinogen for trout hepatoma makes their approximate dietary amounts important. At Hot Creek Hatchery in 1935, salmon egg meal and abalone meal each constituted

about 40 percent dry weight of the diet. In November 1936, Hot Creek yearlings and older rainbow were receiving about 27 percent each of abalone, cottonseed, and salmon egg meals, dry weight. Later that year, the cottonseed meal was replaced by wheat middlings at the same level. At Mt. Shasta Hatchery in December 1937, the diet on a dry weight basis was approximately 24 percent middlings, 24 percent salmon egg meal, 20 percent dry milk, 10 percent kelp meal, 10 percent beef liver, and 5 percent canned sardines. These figures are approximations, but they indicate that the percentages of the suspected meals were usually quite high.

DISCUSSION

Oxidized Foods

The change from a diet of raw and frozen food to one containing a high proportion of dry ingredients in 1937 deserves closer scrutiny. Because of great surface area and exposure to air, the fat or lipid in dry rations is often highly oxidized. This is especially true with fish meal, since the lipids are highly unsaturated.

Haven and Bloor (1956) reviewed the evidence and suggested that oxidized lipids and sterols may be potential carcinogens. Fieser *et al.* (1955) demonstrated that oxidized steroids, cholesterol and their derivatives were tumorgenic to mice. Fish meal is rich in cholesterol. Under the stress of rapid growth and with a highly inbred and selected stock of rainbow trout even weak carcinogens merit careful consideration. Sugai *et al.* (1962) showed that fat altered by heat and oxidation greatly enhanced the carcinogenic ability of certain toxic compounds.

Pesticides

During World War II synthetic pesticides began to be widely used. At the present time, we assume that trout food constituents, such as fish meal, cottonseed meal, and wheat middlings, contain residues of various pesticides and that some of these may be carcinogenic. A careful analysis of the literature leads us to conclude that arsenical sprays are the only ones of those used prior to World War II worth serious consideration. Cotton was sprayed with arsenic to control bollweevils during the pre-war era. Attempts to discover whether pre-war cottonseed meal was tested for arsenic have yielded no results. Although house-fly sprays containing pyrethrum and kerosene were used in Mt. Shasta Hatchery, they were not used at Hot Creek. No chlorinated hydrocarbons were used as insecticides during the pre-war epizootic.

Solvent Residues

The preponderance of cottonseed is solvent-extracted to remove oil by two procedures: direct solvent extraction, and prepressing followed by solvent extraction. In both methods, traces of solvent residues, depending on their quality, remain in the finished cottonseed meal. Although no one has demonstrated that any residues harmful to animals are present, high-boiling-point hydrocarbons may remain in the meal and be implicated in the recent hepatoma epizootic. This possibility remains to be investigated. In the incidents described during the

period 1934–42, it is impossible that solvent residues in the cottonseed meal were involved because the first solvent-extraction cottonseed meal plant began operating in 1948, more than 4 years after the first outbreak of hepatoma in California (Cofield, 1950).

Viruses

The possibility that a virus is implicated in trout hepatoma seems rather remote, although the 1936-42 epizootic yields little information which would help clarify this point.

Strain of Trout

Work is in progress which may help to clarify the problem of "strain" susceptibility to hepatoma. Most studies in this field have been made with selected, rapidly-growing stocks of domesticated rainbow. Heston (1963) presents evidence that rapidly-growing mice suffer a higher incidence of hepatoma than do mice under comparable conditions which grow more slowly. Since trout hepatoma is associated with rapid growth, it is most important to determine whether there is a casual relationship.

Water Temperature

Hepatoma develops much more rapidly at high temperatures than at lower temperatures. We have no evidence that the incidence of hepatoma is correlated with temperature; nevertheless, this is a possibility which should be investigated.

Water Chemistry

Water chemistry might conceivably be involved in carcinogenesis of trout, but considerable differences between dissolved solids of Hot Creek and Mt. Shasta Hatchery water minimize this possibility.

Food Spoilage

Throughout the pre-war period storage facilities for dry meals were inadequate. Dry meals were commonly held for months in rather warm, moist atmospheres which were conducive to development of bacteria and molds. Considerable amounts became spoiled and were discarded, but some meals containing abundant microorganisms may have been used. In the light of recent investigations, some of the meals fed to these trout could have contained *Aspergillus flavus*, or other molds. Aflatoxin, the toxic metabolite of some of these molds, is known to be carcinogenic for warmblooded animals (Austwick and Ayerst, 1963; Richardson *et al.*, 1962; Stovell and Wood, 1963). It is also known to produce hepatoma in trout (Ashley *et al.*, 1964).

Recently (Sinnhuber *et al.*, 1965), aflatoxin was found in a commercial trout ration that was causing hepatoma in rainbow trout. Cottonseed meal, a component of the commercial trout ration was found by chemical and duckling assay to contain aflatoxins. Diets containing these materials and a purified test diet to which aflatoxin had been added produced microscopic liver tumors in 6 months and gross lesions of hepatocarcinoma in 7 months.

REFERENCES

Ashley, Lawrence M., John E. Halver and Gerald N. Wogan. 1964. Hepatoma and aflatoxicosis in trout. Fed. Proc., 23 : 105.

Austwick, P. K. C., and G. Ayerst. 1963. Groundnut microflora and toxicity. Chem. and Ind., 2 : 55–61.

Cofield, E. P., Jr. 1950. The solvent extraction of oilseed. Georgia Institute of Technology, 12 : 1–103.

Fieser, L. F., T. W. Greene, F. Bischoff, G. Lopez, and J. J. Rupp. 1955. A carcinogenic oxidation product of cholesterol. J. Am. Chem. Soc., 77 :3928–3929.

Haven, F. L., and W. R. Bloor. 1956. Advances in cancer research. New York, Academic Press, Inc., 4 : 237–314.

Heston, W. E. 1963. Complete inhibition of occurrence of spontaneous hepatoma in highly susceptible (C3HfxYBR)F1 male mice by hypophysectomy. J. Nat. Cancer Inst., 31 : 467–474.

Hueper, W. C. and W. W. Payne. 1961. Observation on the occurrence of hepatoma in rainbow trout. J. Nat. Cancer Inst., 27 : 1123–1135.

Richardson, L. A., Stella Wicks, Jackie Godwin, and K. R. Pierce. 1962. Effect of mold diet and moldy soybean meal on the growth of chicks and poults. J. Nutrition, 78 :301–306.

Sinnhuber, R. O., J. H. Wales, R. H. Engebrecht, D. F. Amend, W. D. Kray, J. L. Ayres, and W. E. Ashton. 1965. Aflatoxins in cottonseed meal and hepatoma in rainbow trout. Fed. Proc., 24 : 627.

Stovell, P. L. and A. J. Wood. 1963. Studies on fungal toxicosis (poisoning). Western Fur Farmer, 2 : 22–25

Sugai, M., L. A. Whitting, H. Tsuchiyama, and F. A. Kummerow. 1962. The effect of heated fat on the carcinogenic activity of 2-acetylamino-fluorene. Cancer Res., 22 : 510–519.

Wales, J. H. and R. C. Lewis. 1935. Progress report of trout feeding experiments. Calif. Fish and Game, 21 : 110–124.

Wolf, Harold and E. W. Jackson. 1963. Hepatoma in rainbow trout : descriptive and experimental epidemiology. Science, 142 : 666–678.

Calif. Fish and Game, 52(2):92–110, 1966.

ANNOTATED LIST OF FISHES COLLECTED BY MIDWATER TRAWL IN THE GULF OF CALIFORNIA, MARCH–APRIL 1964[1]

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More than 55 species of fish representing 49 genera and 35 families were taken with a midwater trawl in the Gulf of California during March and April 1964. These were caught in 13, 1-hour tows that were made 130 to 250 fathoms (240–460 m) beneath the surface and 12, 30-minute tows at or near the surface. Some of the fishes are new to science, and others represent first records for the Gulf.

During Cruise 64A2 of the California Department of Fish and Game research vessel *Alaska* (March 26 to April 23, 1964), the fish fauna of the Gulf of California was sampled with an assortment of gear. Twenty-five sets were made with a midwater trawl, 12 tows with an otter trawl, 2 tows with a beam trawl, and a blanket net was set 8 times. In addition, shore collections (primarily for fish) were made at four localities, and various individuals always fished with hook and line at the different anchorages. In this report, only the fish catches made with the midwater trawl will be discussed in detail.

METHODS AND RESULTS

Twelve of the 25 tows with the midwater trawl were made at or near the surface. For these, the net was paid out until it was approximately 300 feet astern of the vessel, and the vessel engines were run at 300 rpm. The cork line of the net rode at or near the surface and the net opening, approximately 35 feet square, sampled the upper 15m of the water column. The net and its fishing capabilities have been described by Best and Smith (1965). A typical surface tow lasted 30 minutes.

For making a deep haul, 300 to 500 fathoms of towing cable were paid out, and the engine speed was set at 200 rpm. At this speed, fishing depths seldom were shallower than 240 m (with 300 fathoms of towing cable) or deeper than 460 m (with 500 fathoms of cable out); however, when the vessel was slowed to retrieve the gear after an hour of fishing at the selected depth, the net would travel forward and down, and thus would fish somewhat deeper. At Station 16, for example (Table 1), we determined our trawling depth was 275 m (by measuring cable angle) where our PDR (Precision Depth Recorder) showed a constant bottom depth of 220 fathoms (400 m). During retrieval, the net actually traveled to the bottom where it rode for sufficient time to pick up several thousand heart urchins (*Brisaster*

[1] Submitted for publication, September 1965.

TABLE 1

Data for Midwater Trawiing Stations, Cruise 64A2, Gulf of California

Station	Location	Position		Date (1964)	Time (PST)	Capture depth (m)	Water depth (m)
		Lat. (N)	Long. (W)				
1	4 mi. NE of Inner Gorda Bank	23° 05′	109° 28.7′	29 March	2325–2400	0–15	78–80
4	28 mi. off Los Frailes towards Mazatlan	23° 21′	108° 54′	30 March	1810–1910	0–310	2650–2560
5	50 mi. offshore, 20 to 25 mi. upcoast from Mazatlan			31 March	0125–0525	0–365	823–732
10	Outside San Carlos Bay	27° 52.5′	111° 01′	4 April	1815–1900	0–15	76–90
11	2 mi. E of S end of San Pedro Nolasco Island to 1 mi. off N end	27° 57′	111° 20′	4 April	2055–2125	0–15	220–115
15	Off SE end of Tiburon Island	28° 45.4′	112° 16′	5 April	2000–2030	0–15	24–26
16	Midway between south tips of Tiburon and Angel de la Guardia Island	28° 55′	112° 50.5′	6 April	0025–0125	0–275	402–412
19	Ballenas Channel, 3 mi. inside S tip of Angel de la Guardia Island	28° 58′	113° 11.4′	6 April	2110–2210	0–455	1280
27	17 mi. off San Juan Bautista Point	28° 07′	112° 30′	9 April	1510–1610	0–365	1052–950
28	20 mi. off Trinidad Point	27° 55′	112° 22.5′	9 April	1830–1930	0–365	905–914
30	7 mi. E of San Marcos Island	27° 12.8′	111° 55.1′	10 April	1603–1703	0–350	1143–1214
31	5 mi. SE of Santa Inez Point	27° 03.3′	111° 52.1′	10 April	1815–1815	0–15	285–45
46	14 mi. off N end of Carmen Island	26° 16.3′	110° 57.6′	13 April	1730–1830	0–350	823–732
47	6 mi. off N end of Carmen Island	26° 05.5′	110° 58′	13 April	2000–2010	0–210	732
50	Channel between Danzante and Carmen Island	25° 49.1′	111° 15.5′	14 April	1800–1830	0–15	146–183
51	5 mi. inside Monserrate Island	25° 42′	111° 05.7′	14 April	2117–2147	0–15	220–200
52	3.5 mi. N of Aqua Verde Bay	25° 35′	111° 04.5′	14 April	2255–2325	0–15	128–229
55	4 to 7 mi. off Santa Cruz Island	25° 21′	110° 18.6′	15 April	1610–1710	0–238	750–805
56	8 mi. outside San Jose Island	25° 05′	110° 29′	15 April	2010–2110	0–430	1163–1280
58	3 mi. inside N tip of Partida Island	24° 35′	110° 27′	16 April	1925–1955	0–15	200–137
59	2 mi. off Ballena Island (N of La Paz)	24° 29′	110° 26′	16 April	2040–2110	0–15	110–82
60	3 mi. inside N end of Ceralbo Island	24° 20′	109° 59′	17 April	2000–2030	0–15	567–512
61	1¼ mi. inside Ceralbo Island	24° 13′	109° 55.5′	17 April	2130–2200	0–15	256–229
64	SE of Ceralbo Island	23° 58′	109° 35.2′	18 April	1710–1810	0–457	1005–1097
65	12 mi. off Pescadero Point	23° 53′	109° 31′	18 April	1922–2030	0–457	1188–1646

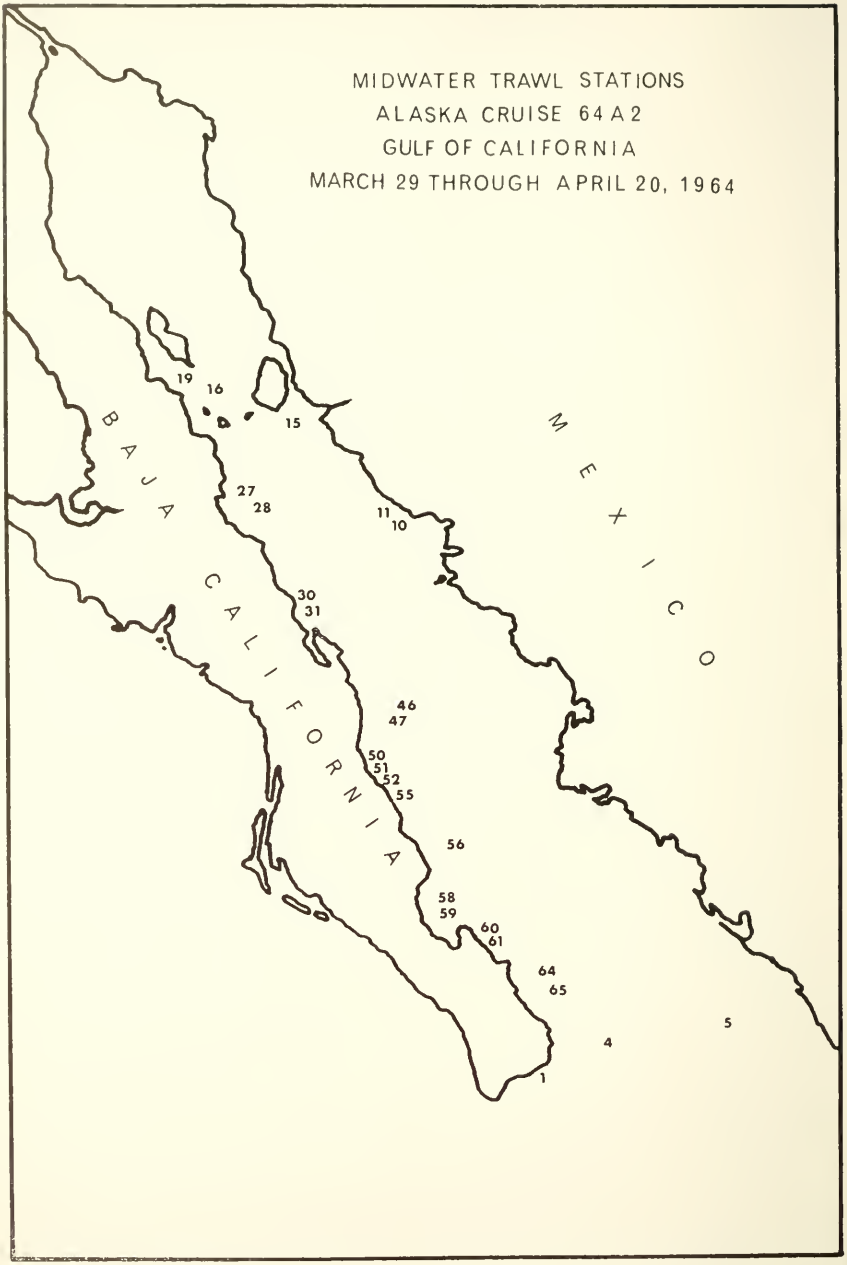

FIGURE 1. Midwater trawl stations occupied in the Gulf of California during March and April 1964.

sp.), a half-dozen mollusks (*Trophon* sp., *Philine* sp., and some tectibranchs), and several kinds of bottom-living fishes (Table 2). The net lacked a closing device so there was no way to determine the depth where any particular fish or species was caught; the net was fishing during the entire period it was under water.

All midwater trawling was conducted during hours of darkness, but in some cases the gear was being set as the sun went down or was being retrieved at dawn. At Station 65 (Table 1) we varied our usual routine of fishing at a single depth for the entire hour, and fished 20 minutes at each of three depths (275, 365, and 460 m) by paying out 300, 400, and 500 fathoms of cable, respectively. The catch (Table 2) was lighter both numerically and specieswise than that of Station 64, made a few hours earlier in the same vicinity at a constant depth (460 m).

Catches of midwater species varied considerably, depending primarily upon locality, tidal conditions, and fishing depth. In the southernmost one-fourth of the Gulf, deep tows usually produced 10 to 15 species of midwater fishes, but the most abundant single species seldom exceeded 1,000 specimens (Figure 1 and Table 2). In the northern Gulf, we took fewer midwater species, but in several cases, catches of *Triphoturus mexicanus* exceeded an estimated 10,000 individuals.

Midwater species were taken in all 13 of the deep tows and in 8 of the 12 surface tows. (*Benthosema panamense* and *Trichiurus nitens* are considered midwater species in this presentation.) One surface tow (Station 1) yielded nothing but pelagic red crabs (*Pleuroncodes planipes*), and one deep tow (Station 55) yielded only two kinds of fishes (*Vinciguerria lucetia* and *Merluccius angustimanus*) and a few squids.

The presence of middepth species at the surface has two logical explanations: (i) species such as *Benthosema panamense* undoubtedly undertake diurnal migrations, but sometimes they remain at or near the surface even during daylight hours (Alverson, 1961); and (ii) tidal changes in the upper Gulf often are so violent that vast expanses will take on the appearance of a churning Maelstrom. In one such area covering a surface expanse one-quarter mile wide and several miles long, the *Alaska* while traveling on automatic pilot was swung off course, first one way then the other, for as much as 40° of compass on one occasion. Such tidal activities unquestionably will transport fish and other forms of life from the depths to the surface and *vice versa*. On another occasion in the channel west of Angel de la Guardia Island, several attempts to set the midwater trawl met with failure when the churning tidal currents spun the otter boards like propellers and caused extreme tangling of bridles, net, and otter boards.

Several species taken in our midwater trawling operations probably are new to science (*Galeus* sp., and *Sebastodes* spp.), and others represent first records for the Gulf of California. Samples of all the organisms taken during this cruise were saved for additional study. Live sardines and most of the large serranids caught on hook and line were used for blood genetic and behavioral studies by U.S. Bureau of Commercial Fisheries personnel at La Jolla. A representative collection of identified fishes was turned over to the biologist who accompanied us from the Mexican Fish and Game Commission. Cephalopods were sent

TABLE 2

Number of Fishes by Species Taken at Each Midwater-Trawl Station, Cruise 64A2, Gulf of California
(Station Numbers of Surface Tows Given in Boldface)

Species	Station numbers																							
	1	4	5	**10**	**11**	**15**	16	19	27	28	30	**31**	46	47	**50**	**51**	**52**	55	56	**58**	**59**	**60**	**61**	64	65
Scyliorhinidae:																									
Galeus sp.							5																		
Chimaeridae:																									
Hydrolagus colliei							1																		
Albulidae:																									
Albula vulpes				7	36	12	1	14					1				1								
Dussumieriidae:																									
Etrumeus teres												43			30	89	32			15	9		8		
Clupeidae:																									
Unidentified			1																						
Harengula thrissina																	2				221				
Sardinops caeruleus			103				73					143		1	353	396	101			22	14		18		
Engraulidae:																									
Anchoa ischana																					26				
Bathylagidae:																									
Bathylagus nigrigenys		2																						2	5
Leuroglossus stilbius			228					2	1	13	1		30	96					20					1	1
Gonostomatidae:																									
Diplophos proximus																								1	
Vinciguerria lucetia		59	16							6			1	8	3	8		77	18			3	39	18	8
Stomiatidae:																									
Stomias atriventer									1	1	1		9	9					1					2	5
Melanostomiatidae:																									
Bathophilus filifer									1																
Synodontidae:																									
Synodus spp.		1		1			1		1																
Synodus lucioceps						47																			
Myctophidae:																									
Benthosema panamense			29		1		1	6	11	5	34		638	13	2535	192	139		8	133			11		
Diaphus pacificus		6											3	1					1			3		20	3
Diogenichthys laternatus		51	3										1						8			2	1	36	10
Hygophum reinhardti																									1
Hygophum atratum		3												2					1			19		105	1
Lampanyctus idostigma		7											1	5					1					63	24
Lampanyctus parvicauda		6																						18	10
Lepidophanes pyrsobolus		1																						1	
Myctophum a. auroluternatum																								1	
Tripholurus mexicanus		12	3335				166	32	25M	15M	15M		10M	1000					1687					169	24
Scopelarchidae:																									
Scopelarchus nicholsi																			2						1

| | | |

to S. Stillman Berry, Redlands; echinoderms went to Fred Ziesenhenne, Allan Hancock Foundation; portunid crabs were presented to William L. Stephenson, Allan Hancock Foundation; and miscellaneous other groups were distributed to other specialists. Most of the fishes have been placed in the Los Angeles County Museum of Natural History collection.

ANNOTATED LIST OF FISHES

In this listing, enumerated data include the station number in **boldface** type, followed by the number of specimens taken at that station, and the range in standard lengths (SL) in millimeters for these specimens. If measurements other than SL are involved (i.e., total length or fork length), these have been indicated as TL and FL. Thus **10**, 7 (59–61) indicates **Station 10**, 7 specimens, (ranging from 59 to 61 mm SL). When the abbreviation (nm) appears in place of length measurements, the specimens were not measured. An asterisk is used outside the parentheses if all or part of the collection was discarded.

SCYLIORHINIDAE—cat sharks

Galeus sp.

Captures: **16**, 5 (nm).

Remarks: At Station 16, between the southern tips of Tiburon and Angel de la Guardia Islands, the net struck bottom while being retrieved, and five small (less than 10 inches long) blackmouth "filetail" sharks were among the catch. Three of these were sent to Stewart Springer, U.S. Fish and Wildlife Service, Stanford University, who identified them as members of the genus *Galeus*. The specific identification has not been determined and may prove distinct. Springer is currently working on these and other Pacific *Galeus*.

In the same haul, several large hake, *Merluccius angustimanus*, were captured, and one of these spit up a partially-digested *Galeus* of this species.

CHIMAERIDAE—chimaeras

Hydrolagus collici (Lay and Bennett)

Captures: **16**, 1 (nm).

Remarks: We can find only one previous record (Baldwin, 1961) for *H. collici* from the Gulf of California. Baldwin's specimen was from 140 m just south of Tiburon Island; our specimen came from northwest of there in 400 m.

ALBULIDAE—bonefishes

Albula vulpes (Linnaeus)

Captures: **10**, 7 (59–61); **11**, 36 (50–69); **15**, 42 (nm)*; **16**, 1 (60); **19**, 14 (56–67); **46**, 1 (52); **52**, 1 (56).

Remarks: All 102 bonefish taken were leptocephali, and all probably were caught near the surface, even though Stations 16, 19, and 46 were deep tows.

CLUPEIDAE—herrings

Unidentified

Captures: **5**, 1 (16).

Remarks: This larval clupeid was too badly mangled to be identified to genus or species.

Harengula thrissina (Jordan and Gilbert)

Captures: **52**, 2 (80–94)*; **59**, 221 (nm)*.

Remarks: Identifications were made aboard the *Alaska*, but because other collecting methods were yielding quantities of these small clupeids, the 223 specimens listed here were discarded. Both of these collections came from surface tows.

Sardinops caeruleus (Girard)

Captures: **10**, 103 (50–87); **16**, 73 (42–59); **31**, 143 (80–100)*; **47**, 1 (238)*; **50**, 353 (20–97); **51**, 396 (59–113)*; **52**, 104 (75–96)*; **58**, 22 (61–215)*; **59**, 44 (53–195); **61**, 18 (74–88).

Remarks: *Sardinops* was taken only where the net fished less than 15 m beneath the surface, except for Station 16. The 73 post-larvae from this tow undoubtedly were caught as the net was being let out or pulled in. Most sardines taken with the midwater trawl were utilized for blood genetic studies.

DUSSUMIERIIDAE—round herrings

Etrumeus teres (DeKay)

Captures: 31, 43 (80–215)*; 50, 30 (39–107)*; 51, 89 (31–110)*; 52, 32 (93–117)*; 58, 15 (165–228)*; 59, 9 (97–188)*; 61, 8 (61–121)*.

Remarks: *Etrumeus* was taken only in shallow midwater tows where the net fished less than 15 m beneath the surface. Whitehead (1963) was unable to find any differences in the round herrings of the world, and considered *E. acuminatus* (the previously accepted name for the Pacific species) a synonym of *E. teres*. In the southern Gulf, round herring contribute significantly to the diets of billfishes (Istiophoridae).

ENGRAULIDAE—anchovies

Anchoa ischana (Jordan and Gilbert)

Captures: 59, 26 (72–107).

Remarks: The anchovies, genus *Anchoa*, of the Gulf are not easily identified, but these 26 specimens agree well with Hildebrand's (1943) description of *A. ischana*.

BATHYLAGIDAE—blacksmelts

Bathylagus nigrigenys Parr

Captures: 4, 2 (62–79); 64, 2 (59–73); 65, 5 (62–76).

Remarks: The Gulf of California is the type locality for *B. nigrigenys*, a species which might be confused with *B. wesethi* where the two occur together on the outer coast of Baja California. We caught nine of these blunt-nosed, brown bathylagids just inside the mouth of the Gulf, but did not find them farther north. All were captured at dusk between the surface and 440 meters.

Leuroglossus stilbius Gilbert

Captures: 5, 228 (41–83); 19, 2 (55–71); 27, 1 (24); 28, 13 (46–81); 30, 1 (23); 46, 30 (44–80); 47, 96 (40–78); 56, 20 (42–76); 64, 1 (65); 65, 1 (48).

Remarks: Smoothtongues were captured throughout the Gulf, but most of the 393 specimens came from deep hauls in the southern portion. All were caught during operation of the trawl at moderate depths, between 265 and 440 meters, over a bottom greater than 400 fms (732m). At Station 5, in the eastern section of the Gulf north of Mazatlan, 199 of the 207 smoothtongues were typically-colored, iridescent, greenish-brown individuals, but the remaining 8 were weakly pigmented "white" specimens. In coloration they resemble *L. urotranus* Bussing from the Peru-Chile trench, but they possess longer snouts and deeper bodies than the southern hemisphere forms. Bussing (1965) states that *L. urotranus* lacks pigment on the caudal fin rays. Our "white" bathylagids have pigmented areas extending from the base of the caudal onto the fin rays.

GONOSTOMATIDAE—lightfishes

Diplophos proximus Parr

Captures: 64, 1 (85).

Remarks: Grey (1960) listed the known records of *Diplophos* from the Pacific Ocean and assigned them to the *D. taenia* complex with some reservations. Later, Grey (1964) called all the Atlantic members of this complex *D. taenia*, and referred the Pacific material to one or more species. The Gulf of California is the type locality for *D. proximus*, so we are using this name here. Future revision of this group may show that our specimen fits one of the other three Pacific species better.

Vinciguerria lucetia (Garman)

Captures: 4, 59 (22–54); 5, 16 (22–52); 28, 6 (27–39); 46, 1 (31); 47, 8 (29–45); 50, 3 (32–50); 51, 8 (27–57); 55, 77 (25–49); 56, 48 (30–46); 60, 3 (21–37); 61, 39 (21–49); 64, 18 (23–42); 65, 8 (26–31).

Remarks: None of our records adds materially to the distribution given by Ahlstrom and Counts (1958). Taking *V. lucetia* in surface tows (Stations 50, 51, 60, and 61) is not unusual. These small lightfishes often are attracted to a night-light and can be dipnetted at the surface; at other times, the stomachs of surface-feeding tunas are glutted with them. Occasional specimens have been found in stomachs of porpoises (*Stenella* sp.) netted off Acapulco, Mexico.

STOMIATIDAE—scaly dragonfishes

Stomias atriventer Garman

Captures: 27, 1 (159); 28, 1 (170); 30, 1 (136); 46, 9 (105–150); 47, 9 (108–170); 56, 1 (207); 64, 2 (67–128); 65, 5 (96–171).

Remarks: Blackbelly dragonfish were taken consistently along the western side of the Gulf, and most of the 29 individuals were large adults; only one was a juvenile. *S. atriventer* was described from the Gulf.

MELANOSTOMIATIDAE—scaleless dragonfishes

Bathophilus filifer (Garman)

Captures: 27, 1 (70).

Remarks: *B. filifer* has been known from the eastern Pacific off Central America (lat. 16° N.). Ours, taken off San Juan Bautista, is the first record of the species in the Gulf of California. Ebeling (1962) gave the range as lat. 20° N., but did not cite a specific record (capture). Morrow (1957) recorded a single specimen from lat. 04° S., off the coast of Peru, so *B. filifer* ranges from there to lat. 28° N., at least.

SYNODONTIDAE—lizardfishes

Synodus spp.

Captures: 4, 1 (47); 10, 1 (30) 16, 1 (62); 27, 1 (29).

Remarks: These four post-larval lizardfishes were lacking in adult characters, and shall remain unidentified until more knowledge is available on the early stages of the Pacific species. Based upon pigmentation, more than one species is represented.

Synodus lucioceps (Ayres)

Captures: 15, 47 (53–89).

Remarks: Within this size range, a number of specimens showed adult characters, so the specific identification was relatively simple for these.

MYCTOPHIDAE—lanternfishes

Benthosema panamense Taning

Captures: 5, 29 (33–49); 11, 1 (28); 16, 1 (30); 19, 6 (24–37); 27, 11 (28–43); 28, 5 (25–33); 30, 34 (24–38); 46, 638 (28–52); 47, 43 (28–44); 50, 2535 (nm); 51, 192 (nm)*; 52, 139 (nm)*; 56, 8 (24–45); 58, 133 (24–39); 61, 11 (25–54).

Remarks: Alverson (1961) mentioned the habit this species has of occurring at the surface in dense schools (balls) during daylight hours, so their capture in 6 of our 12 surface tows (Stations 11, 50, 51, 52, 58, and 61) was not unusual; in fact, only one deep tow (46) yielded more than 100 individuals, but four shallow tows exceeded that number and one (50) produced 2,535. *B. panamense* otoliths have been found abundantly in porpoise (*Stenella* sp.) stomachs on several occasions: a porpoise from off Costa Rica contained 2,357 otoliths (sagittae), while another from off Acapulco contained 1,238.

Diaphus pacificus Parr

Captures: 4, 6 (21–28); 46, 3 (26–30); 47, 1 (30); 56, 1 (31); 60, 3 (27–30); 64, 20 (25–36); 65, 3 (24–29).

Remarks: *Diaphus pacificus* was described from one individual taken off the west coast of southern Mexico (Parr, 1931). Beebe and Vander Pyl (1944), who obtained 19 specimens just north of the type locality, remarked on only a single characteristic of this species, i.e., the variation in the number of luminescent organs, presumably those of the anal series. Fowler (1944) cited Parr's original description in a checklist of eastern north Pacific fishes, but incorrectly listed the type locality as off southwest Nicaragua. Wisner (1962) recorded *D. pacificus* from near Socorro Island, and Ebeling (1962) indicated the species ranged from lat. 04° N. to lat. 20° N. in the eastern north Pacific Ocean, based on Scripps Institution of Oceanography specimens. Our 37 individuals represent the first records for *D. pacificus* in the Gulf of California and the first from north of lat. 20° N. Since the species description was based upon a single specimen and has never been elaborated upon, additional discussion and redescription seem desirable at this time.

Fraser-Brunner (1949) recognized four subgenera of *Diaphus*, but Bolin (1959) divided the genus into three genera (*Lobianchia, Diaphus, Aethopora*) and gave brief diagnoses of these genera. According to Bolin's generic descriptions, our 37 Gulf headlightfish are typical *Diaphus*, showing the peculiar forward bend of the premaxillary teeth. Neither Fraser-Brunner (1949) nor Bolin (1959) included *D. pacificus* in their revisions.

Diaphus pacificus Parr

Diaphus pacificus Parr 1931, Bull. Bingham Oceanogr. Coll., 2(4) : 34 (type locality : lat. 16° 14′ N., long. 99° 36.5′ W.). Beebe and Vander Pyl 1944, Zoologica, 29(9) : 90 (photophore variation and additional specimens). Fowler 1944, Monog. Acad. Nat. Sci. Philadelphia, 2 : 490 (lists type specimen, incorrectly states type locality). Ebeling 1962, Dana Rept., (58) : 140 (distribution and additional specimens). Wisner 1962, Limnol. Oceanol., Suppl., 7 : xli (distribution and additional specimens).

Holotype: Bingham Oceanographic Collection No. 2690.

Diagnosis: The genus *Diaphus* as diagnosed by Bolin (1959) includes 11 species : *andersoni* Taning ; *brachycephalus* Taning ; *fulgens* (Brauer) ; *holti* Taning ; *mollis* Taning ; *nanus* Gilbert ; *pacificus* Parr ; *parri* Taning ; *rafinesquei* (Cocco) ; *theta* Eigenmann & Eigenmann ; and *vanhoeffeni* (Brauer). Four of these species (*fulgens, nanus, pacificus, rafinesquei*) have an abruptly elevated first AOa photophore. *D. pacificus* has fewer gill rakers (5-7+1+12-14) than *rafinesquei* (7-8+1+14-15), and has fewer pectoral fin rays (9-10) and lateral line scales (30-33) than either *nanus* (12 and 36) or *fulgens* (11-12 and 35).

Description: Body robust, greatest depth immediately anterior to dorsal fin origin, tapering gradually to caudal peduncle. Head moderately blunt ; dorsal profile rounded above orbit, increasing slightly to nape ; mid-interorbital region flattened, marked anteriorly by a weak ridge along midline, marked posteriorly by nape musculature which extends to back of orbit ; ventral profile rises gently to lower jaw ; posterior opercular edge pointed and smooth ; snout blunt and rounded. Snout length much less than interorbital width. Eye diameter moderate. Nares situated directly in front of eye in upper corner of snout. Jaws subequal, extending well behind orbit. Premaxillary teeth in a narrow band, small, and close-set ; inner teeth under midorbit with abrupt bend which is directed anteriorly. Teeth of lower jaw in broad band, similar in shape to those of premaxillary, but not hooked anteriorly. No vomerine teeth. A narrow band of teeth on palatines. A small patch of teeth on pterygoids.

Scales cycloid, thin, completely covering body ; deciduous, most lost, many remain along lateral line ; moderately large. Four scale rows above lateral line and five below.

Lateral line complete, its shallow, trough-type canal extends from top of preopercle to caudal fin ; canal roofed over by 30 to 33 pored scales which extend to posterior margin of caudal peduncle.

Four complete gill arches ; a fifth arch has no posterior slit but bears several rakers. Small pseudobranch present. Gill rakers well-developed on first arch, moderately long and tapering to a point, broad at base, thin and close-set ; rakers rudimentary on remaining arches ; all rakers have spinate medial edges, lateral external edges smooth.

Dorsal fin origin in advance of center of body ; anal fin origin on posterior third of body, always behind dorsal fin, usually under SAO_2 ; dorsal adipose fin located above a vertical between end of anal fin and AO_{3}, always behind anal fin, sometimes over AO_3 ; pelvic fins inserted on ventral surface of body, beneath 2nd to 4th dorsal rays ; pectoral fins originate beneath or just posterior to tip of opercle, anterior margin of fin base inserted about one-fifth of distance up side of body, fin base vertical on body. Pectoral fins short, rays fail to reach pelvic fin origin. Pelvic fin rays reach anal origin.

Inner surface of peritoneum heavily pigmented, appearing solid dark-brown. Five large, unbranched pyloric caeca present.

Photophores: The terminology and abbreviations of luminescent organs are those of Fraser-Brunner (1949). Photophores on the head include : one Dn, above, smaller, and always separate from Vn, although occasionally in close contact ; one large Vn ; a small So, directly behind Vn ; three Br ; and two Op. Luminescent organs present on the body are : a PLO, behind projection of operculum on midline of body ; two PVO, PVO_1 anterior to PVO_2, PVO_1, PVO_2, and PO_1 form a diagonally straight line ; five PO, PO_4 elevated to a level with PVO_2 or a little higher, always over or just behind PO_3, PO_5 slightly above a horizontal formed by PO_1, PO_2, and PO_3 ; VLO on midline, falling on a vertical formed by PLO, VO_2, and SAO_2 ; five VO, VO_3 between pelvic fin bases, VO_2 and VO_3 elevated in a gentle arch, VO_3 elevated above VO_2 in line with VLO and SAO_2, may fall above or below a horizontal formed by PLO, VLO, and SAO_2 but never by a full organ's width ; SAO series forming a straight line, SAO_1 directly behind and a little above VO_5 ; four to five AOa,

AOa_1 abruptly elevated to a level just beneath SAO_2, SAO_2 could be considered in the horizontal formed by PLO, VLO, VO_3, and SAO_2; AOa_{2-5} forming a gentle arch upwards toward Pol; three to five AOp, always in a straight line; one Pol on a horizontal level formed by SAO_3 and Prc_4; four Prc, progressively decreasing in size from Prc_1 to Prc_4.

Measurements: Measurements are based on 12 specimens 25 to 34. 7 mm SL, expressed in percentage of SL: head length, 30.3–34.0; snout length, 4.1–5.5; eye diameter, 6.3–9.7; interorbital width, 10.0–13.4; length of upper jaw, 20.1–23.2; predorsal length, 41.2–45.6; pre-anal length, 65.3–72.0; pre-pectoral length, 30.2–34.0; pre-pelvic length, 43.5–49.2; pre-adipose length, 78.6–82.4; dorsal fin base length, 20.0–26.1; anal fin base length, 13.8–16.5; greatest depth of body, 22.1–28.8; least depth of caudal peduncle, 11.5–14.2; and length of caudal peduncle, 18.9–22.3.

Counts: Counts for 28 of our specimens are: D, 13–14; A, 11–13; P, 9–10; V, 8; gill rakers, 5–7+1+12–14; branchiostegal rays, 8–9; 30–33 vertebrae, of which 16–18 are caudal; pored lateral line scales, 30–33.

Color in alcohol: Body a deep-brown with a random pattern of darker pigment spots profusely scattered over entire fish. Flecks of black pigment on median fins. Scales colorless.

Distribution: Diaphus pacificus is known from the Gulf of Panama, off Colombia, to north of Socorro Island and in the Gulf of California. Its depth distribution is less well known. The type was taken in a haul with 625 fathoms (1,143 m) of wire out. Beebe and Vander Pyl (1944) captured their specimens somewhere between the surface and 300 to 400 fathoms (549–732 m). Ebeling (1962) gave no depth records. Wisner (1962) took 10 individuals in three hauls between the surface and 183 meters, and 43 specimens in a tow between the surface and 1,509 meters. At all stations except one (60), we took *D. pacificus* between the surface and 210–457 meters. At station 60 we netted three specimens in a surface tow (15 meters deep).

Discussion: Parr's (1931) description of *D. pacificus* generally is adequate, but four of the characteristics he gives appear to diverge widely among our 37 specimens or are incorrectly stated: (i) the proportion given for snout length, expressed in percent of SL, is 7 in the type while we find a range of 4.1 to 5.5; (ii) the pelvic fins were said to originate anterior to the dorsal insertion, but in all ours they were behind the dorsal origin; (iii) the anal origin was said to be beneath or immediately behind the last dorsal ray, whereas on ours there was good separation between the last dorsal ray and the anal origin; and (iv) in the illustration of the type the VLO is not on a horizontal with the PLO, VO_3, and SAO_2 as it should be.

Generally the females of *D. pacificus* are more robust than the elongate, narrow-bodied males. We found that females typically possess four AOa organs while males have five, but in three of our specimens (two males and one female) this pattern was reversed.

Diogenichthys laternatus (Garman)

Captures: 4, 51 (17–27); 5, 3 (26–27); 46, 4 (27–28); 56, 8 (24–29); 60, 2 (20–24); 61, 1 (29); 64, 36 (23–29); 65, 10 (25–28).

Remarks: All *Diogenichthys* captured in the Gulf possessed an angular SAO photophore series. On those in which the SAO series approached a slightly-bent condition, SAO_1 was always over or just behind VO_4, never in an advanced position. All of these robust lanternfish also had juxtaposed Prc organs typical of *D. laternatus*.

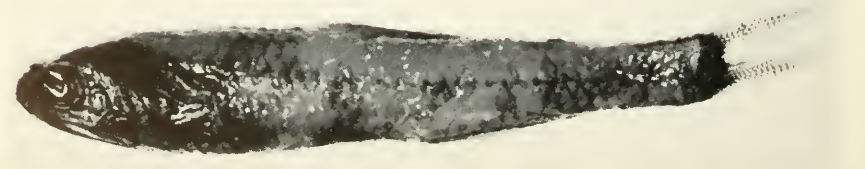

FIGURE 2. *Lampanyctus parvicauda* 89 mm SL captured at lat. 23° 53′ N., long. 109° 31′ W., Gulf of California, April 18, 1964 between the surface and 457 m. *Photo by Armando Solis.*

Hygophum reinhardti (Lütken)

Captures: 65, 1 (25).

Remarks: This small *Hygophum* had 3 AOp over the anal fin, a strongly-angulated SAO series (SAO_1 level with SAO_2), 5+1+17 gill rakers, and was slightly more elongate than *H. atratum*. Although Bolin (1959) decided that *H. reinhardti* was confined to the Atlantic Ocean, Becker (1965) places the species in the eastern north Pacific also. This small female keys out to *H. reinhardti* in Becker's publication.

Hygophum atratum (Garman)

Captures: 4, 3 (42–57); 47, 2 (54–56); 56, 1 (36); 60, 19 (30–60); 64, 105 (28–63); 65, 1 (41).

Remarks: Following Becker (1965), we are assigning the name *H. atratum* to our material. This species can be attracted to the surface at night by suspending a bright light above the water (Fitch, 1951).

Lampanyctus idostigma Parr

Captures: 4, 7 (56–80); 46, 1 (66); 47, 5 (68–82); 56, 1 (59); 64, 63 (32–81); 65, 24 (26–86).

Remarks: At first glance, *L. idostigma* might be confused with *L. ritteri*, but the two differ in many respects: *L. idostigma* has a more widely-spaced and less strongly-angulated SAO series, fewer dorsal rays, fewer infracaudal glands, more AO photophores, more gill rakers on the lower limb of the first gill arch, and somewhat larger, more-deciduous scales than *L. ritteri*. In life, *L. idostigma* is quite black, whereas *L. ritteri* is a deep-brown.

Lampanyctus parvicauda Parr (Figure 2)

Captures: 4, 6 (42–91); 64, 18 (43–99); 65, 10 (40–94).

Remarks: Based upon its otoliths (sagittae), *L. parvicauda* is strikingly different from all other eastern Pacific members of the genus (Figure 3). Because of these differences, we are planning to investigate "*Lampanyctus*" otoliths further, to see if they can be correlated with characters historically used in *Lampanyctus* identification, but this will not be possible until comparative material has been

FIGURE 3. Otoliths (sagittae) of *Lampanyctus leucopsarus* (upper left), *L. regalis* (lower left), *L. parvicauda* (upper right), and *Ceratoscopelus townsendi* (lower right). *C. townsendi* at one time was considered a typical "*Lampanyctus*." Photo by Jack W. Schott.

obtained from freshly caught (non preserved) species of *Lampanyctus* from all world oceans.

Lepidophanes pyrsobolus Alcock
Captures: 4, 1 (31); 64, 1 (31).
Remarks: These two specimens represent the first record for the species from the Gulf, although Bolin (1959) states that *L. pyrsobolus* is circumtropical between lat. 35 N. and lat. 35 S. In life, they are dark-brown with violet-blue photophores.

Myctophum a. aurolaternatum Garman
Captures: 64, 1 (14).
Remarks: In localities where *M. aurolaternatum* occurs, it can be attracted to the surface at night by a bright light suspended above the water (Clemens and Nowell, 1963).

Triphoturus mexicanus (Gilbert)
Captures: 4, 12 (28–46); 5, 3335 (nm); 16, 166 (26–62); 19, 32 (29–55); 27, 25000 (22–60)*[2]; 28, 15000 (nm)*[2]; 30, 15000 (24–61)*[2]; 46, 10000 (28–69)*[2]; 47, 1000 (nm); 56, 1687 (21–70); 64, 169 (24–64); 65, 24 (26–64).
Remarks: *T. mexicanus* was exceedingly abundant at certain localities in the Gulf, always associated with large quantities of the natant decapod, *Sergestes*. Large hake taken in our deep tows often had their stomachs full of *Triphoturus* and *Sergestes*. Between San Juan Bautista Point and Carmen Island, the population of *T. mexicanus* must be immense. At Stations 27, 28, 30, and 46 an estimated 25, 15, 15, and 10 thousand individuals were taken in tows lasting 1 hour each at fishing depth.

SCOPELARCHIDAE—pearleyes

Scopelarchus nicholsi (Parr)
Captures: 56, 2 (33–103); 65, 1 (104).

CONGRIDAE—congers

Leptocephali
Captures: 4, 5 (69–115); 5, 13 (82–170); 19, 2 (74–106); 27, 1 (108); 46, 3 (71–124); 47, 5 (69–139); 52, 1 (81); 60, 92 (64–207); 61, 59 (45–211); 64, 11 (84–177); 65, 5 (74–135).
Remarks: Based upon pigmentation, myomere counts, body lengths and depths, and head and jaw shapes, eight different species of eels are represented in these collections. Historically, eel leptocephali have been placed in family Congridae; none of our specimens is a nemichthoid (suborder Nemichthyoidei).

Uroconger varidens Garman
Captures: 5, 1 (130).
Remarks: This small eel agrees very well with the printed description of the type specimen, and with material from the Peru-Chile Trench, the southern limit of its range.

OPHICHTHIDAE—snake-eels

Ophichthus zophochir (Jordan and Gilbert)
Captures: 11, 1 (389).
Remarks: *O. zophochir* usually is taken during bottom trawing operations, but this individual was netted within 15 m of the surface in 115 to 220 m of water. Hopkirk (1965) gave an excellent description of this species.

NEMICHTHYIDAE—snipe-eels

Nemichthys scolopaceus Richardson
Captures: 56, 5 (705–1090); 64, 1 (713); 65, 1 (348).
Remarks: *N. scolopaceus*, a world-ranging species, usually is caught by trawling at least 1,000 feet (300m) beneath the surface, but during 1962 a 30-inch female was sent to California State Fisheries Laboratory for identification. It had been spit-up by a rockfish (*Sebastodes* sp.) that had been caught on the bottom in 130 fathoms of water off Anacapa Island, California. In 1964, a similar-sized snipe-eel was caught by a commercial fisherman in a nighttime purse-seine set off the Coronado Islands, Baja California, and in 1965, four snipe-eels were caught in surface tows (three stations) with a midwater trawl near Canoas Pt., Baja California, where the water was only 42–48 fms deep (77–88m).

[2] At Stations 27, 28, 30, and 46, only a portion of the catch was counted: 2,641; 1,289; 874; and 185 individuals respectively.

MERLUCCIIDAE—hakes

Merluccius angustimanus Garman

Captures: 16, 985 (nm)[3]; 19, 2 (150–153); 27, 5 (nm); 28, 20 (nm)*; 30, 5 (nm)*; 46, 13 (364–391 TL)*; 47, 16 (395–525 TL)*; 55, 1 (28).

Remarks: When these Gulf hake were keyed-out in Ginsburg's (1954) publication on the American members of the family, they fitted *M. angustimanus* best, but some individuals seemed to affiliate with characters he gave for *productus*, while others were not readily distinguishable from *gayi*. Ramirez *et al.* (1965) list the Gulf hake as *M. productus*.

BREGMACEROTIDAE—pelagic codlets

Bregmaceros bathymaster Jordan and Bollman

Captures: 64, 1 (53); 65, 1 (45).

Remarks: Although both these specimens were taken in deep tows, *B. bathymaster* is easily attracted to the surface at night by a bright light suspended above the water (Clemens and Nowell, 1963). Occasionally, tropical tunas feed upon the species. Munro (1950) pointed out that the species inhabiting the eastern tropical Pacific is *B. bathymaster*.

CORYPHAENOIDIDAE—rattails

Coelorhynchus scaphopsis Gilbert

Captures: 16, 92 (72–282).

Remarks: *C. scaphopsis* appears to be the commonest rattail in the upper Gulf, and it has been taken once off southern California, in the vicinity of Santa Barbara.

MELAMPHAIDAE—bigscales

Melamphaes acanthomus Ebeling

Captures: 28, 1 (78).

Remarks: Ebeling (1962) presents catch locality data for this and other Gulf-inhabiting melamphaids.

Melamphaes macrocephalus Parr

Captures: 4, 2 (49–57); 64, 1 (67); 65, 4 (52–62).

Remarks: *M. macrocephalus* is easily confused with *M. polylepis*. The only certain way to distinguish the two is to X-ray them and look for the anterior spur that *M. polylepis* has on the first haemal arch of the first caudal vertebra.

Melamphaes spinifer Ebeling

Captures: 65, 2 (30–31).

Scopelogadus mizolepis bispinosus (Gilbert)

Captures: 4, 27 (29–55); 5, 1 (40); 47, 20 (35–58); 56, 31 (32–64); 64, 83 (25–60); 65, 59 (22–59).

Remarks: This was by far the commonest melamphaid we caught. All came from deep tows in the southern portion of the Gulf.

SPHYRAENIDAE—barracudas

Sphyraena lucasana Gill

Captures: 51, 1 (515 TL).

Remarks: Although Schultz (1953) considered *S. lucasana* a synonym of *S. argentea*, the two species are readily distinguished. *S. lucasana* is a smaller fish, has larger scales, has a darkly-pigmented caudal fin (lacking yellow), and has parr-marks on its sides. The range of *S. lucasana* overlaps with that of *S. argentea* between Magdalena Bay and Cedros Island on the outer coast of Baja California, but it is the only species occurring inside the Gulf. One of the largest individuals we have seen was 697 mm TL and weighed 3 lbs. 1 oz. Ramirez *et al.* (1965) erroneously report the Gulf species as *S. ensis*, but Mazatlan is the farthest north we have any record for *S. ensis*. *S. ensis* differs from all other eastern Pacific barracudas in that the pelvic fins are attached below the tips of the pectorals, well ahead of the first dorsal insertion.

[3] At Station 16, all 16 large hake that were taken were measured (353–880 mm TL as were 237 small ones (34–76 mm SL).

BRANCHIOSTEGIDAE—blanquillos

Caulolatilus princeps (Jenyns)

Captures: 51, 1 (24).

Remarks: The postlarval stages of *C. princeps* apparently are pelagic; a few individuals have been found in the stomachs of albacore caught 100 miles or more off the California coast. Our specimen was caught in a shallow tow within 15 m of the surface. The serrate, bony ridges on the heads of fish this size make them difficult to recognize, because heads of adults are smooth.

CARANGIDAE—jacks

Decapterus pinnulatus (Eydoux and Souleyet)

Captures: 58, 6 (161–178); 59, 2 (183–191).

Remarks: These small scads differ from *D. hypodus* in having 11–12 gill rakers on the upper limb of the first gill arch (*hypodus* has 13–15), in having 115–127 lateral line scales (*hypodus* has 99–116), in having a smaller mouth, and in several other characters. They differ from all other species of *Decapterus* described from the eastern Pacific, but match Hawaiian *D. pinnulatus* quite well, so we use that name here.

Selar crumenophthalmus (Bloch)

Captures: 61, 1 (165).

TRICHIURIDAE—cutlassfishes

Lepidopus xantusi (Goode and Bean)

Captures: 52, 2 (47)*; 64, 1 (55).

Remarks: Juvenile *L. xantusi* are silver-colored and apparently inhabit depths between the surface and 305 m where they occasionally are eaten by tunas (Clemens and Nowell, 1963). As adults, they become darkly pigmented, move to the bottom, and aggregate in schools. A single otter-trawl haul in 140 fathoms (255 m) off Newport Beach, California, in April 1962 caught 1½ tons of *L. xantusi*, weighing perhaps 1½ pounds each. Two of our three juveniles were caught within 15 m of the surface (Station 52).

Trichiurus nitens Garman

Captures: 50, 4 (216–506); 51, 2 (225–410); 52, 12 (322–406); 59, 11 (303–416).

Remarks: Tucker (1956) considered *T. nitens* a synonym of *T. lepturus*, but vertebral counts for eastern Pacific cutlassfishes (141–155) are distinct from those for *T. lepturus* (162–168), and other differences, as pointed out by Hubbs and Hubbs (1941), also appear to be valid.

SCOMBRIDAE—mackerels

Scomber diego (Ayres)

Captures: 10, 159 (50–147); 11, 11 (165–140 FL)*; 31, 31 (240–280 FL)*; 46, 38 (236–290 FL)*; 47, 4 (253–276 FL)*; 51, 121 (22–78 FL); 52, 38 (nm)*; 58, 12 (122–182)*; 59, 1 (162)*; 60, 1 (40); 61, 38 (30–150 FL)*; 64, 4 (23–25).

Remarks: A different mackerel, *S. australasicus*, is abundant at Socorro Island, about 250 miles southwesterly from Cape San Lucas, but *S. diego* appears to be the only mackerel inhabiting the Gulf.

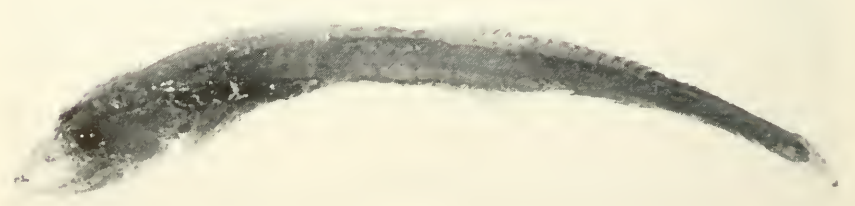

FIGURE 4. *Kali normani* 141 mm SL captured at lat. 33° 25′ N., long. 118° 50′ W., Catalina Basin, California, October 10, 1962 between the surface and 1000 m. *Photo by Armando Solis.*

STROMATEIDAE—butterfishes

Cubiceps gracilis (Lowe)

Captures: 5, 1 (95).

Remarks: This genus badly needs revising, but until such occurs, our small specimen will have to be listed as *C. gracilis*. Its otoliths match those from a large individual netted off Portuguese Bend, California, in 1954.

Palometa media (Peters)

Captures: 59, 3 (155–160).

Remarks: The characters for distinguishing eastern Pacific species of *Palometa* are poor at best. Future work may show that our three specimens are wrongly assigned, but they do fit published descriptions of *P. media* extremely well.

XENICHTHYIDAE—salemas

Xenistius californiensis (Steindachner)

Captures: 51, 1 (125).

CHIASMODONTIDAE—swallowers

Kali normani Parr

Captures: 4, 1 (115); 64, 1 (128).

Remarks: Ebeling (1962) gave the range of *K. normani* as extending from lat. 23° N. to lat. 28° N. based upon five individuals in the Scripps Institution of Oceanography collection. Since 1962, two specimens have been caught in the Catalina Basin (Figure 4) off southern California by personnel from the University of Southern California aboard the *Velero IV*.

URANOSCOPIDAE—stargazers

Kathetostoma averruncus Jordan and Bollman

Captures: 5, 1 (11).

Remarks: This tiny specimen was identified as *K. averruncus* on the basis of finray counts, utilizing data in the recent publication of Fierstine and Werner (1963).

SCORPAENIDAE—scorpionfishes

Sebastodes spp. (Figure 5)

Captures: 16, 18 (44–380); 19, 59 (32–117); 27, 8 (34–47).

Remarks: These 86 specimens represent at least four species; possibly all are new to science, but this will not be known until a review of the Gulf *Sebastodes* and *Pontinus* is available. None of the 49 species of *Sebastodes* covered by Phillips (1957) was listed as ranging into the Gulf.

AGONIDAE—poachers

Xeneretmus ritteri Gilbert

Captures: 16, 2 (112–137).

Remarks: Direct comparisons were made with specimens of *X. ritteri* collected off Santa Monica Bay, California, and Cedros Island, Baja California. The

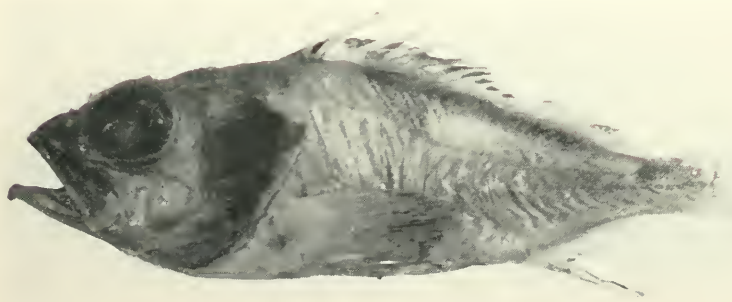

FIGURE 5. *Sebastodes* sp. 157 mm SL captured at lat. 28° 55′ N., long. 112° 50.5′ W., Gulf of California, April 6, 1964 in 402–412 m. *Photo by Armando Solis.*

dorsal fin of *N. ritteri* is black distally, milky-white centrally, and black basally. The fins of the Gulf specimens seemed somewhat more darkly pigmented, but no other differences could be found, including vertebral counts. This is the first record of *N. ritteri* from the Gulf.

CYNOGLOSSIDAE—tonguefishes

Symphurus sp. (Figure 6)
Captures: 16, 15 (67–109).
Remarks: These tonguefishes do not match any described species, but no specific name can be assigned them pending publication of a revision of the genus that was completed several years ago by a graduate student at the University of California, Los Angeles.

BALISTIDAE—triggerfishes

Balistes polylepis Steindachner
Captures: 11, 4 (280–330 TL).

BATRACHOIDIDAE—toadfishes

Porichthys notatus Girard
Captures: 16, 4 (60–170); 19, 2 (73–90).

LOPHIIDAE—anglerfishes

Lophiomus setigerus (Vahl)
Captures: 47, 1 (74).
Remarks: Several adult *L. setigerus* were caught during our otter-trawling operations in the Gulf, particularly near the entrance to Concepcion Bay, but this was the only pelagic juvenile that we collected.

ACKNOWLEDGMENTS

Many individuals contributed to the success of our midwater trawling operations: Ivo Kuselj, skipper of the *Alaska*, and his entire crew deserve very special thanks; biologists A. M. Vrooman, U.S. Bureau of Commercial Fisheries, La Jolla, and Fernando J. Rosales, Mexican Fish and Game Commission, Mazatlan, worked long hours helping sort and preserve catches, standing watches, and attending to a multitude of shipboard chores. Armando Solis, Los Angeles County Museum of Natural History, and Jack W. Schott, California Department of Fish and Game photographed various items for us, and John Paxton, University of Southern California, assisted with some of the myctophid identifications.

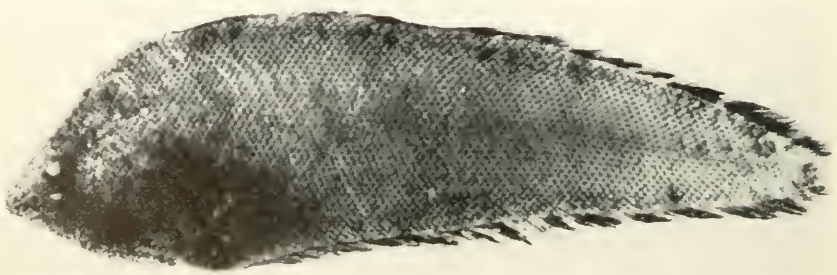

FIGURE 6. *Symphurus* sp. 94 mm SL captured at lat. 28° 55′ N., long. 112° 50.5′ W., Gulf of California, April 6, 1964 in 402–412 m. Photo by Armando Solis.

REFERENCES

Ahlstrom, Elbert H., and Robert C. Counts. 1958. Development and distribution of *Vinciguerria lucetia* and related species in the eastern Pacific. Fish. Bull., U.S. Fish and Wildl. Serv., 58(139) : 363–416.

Alverson, Franklin G. 1961. Daylight surface occurrence of myctophid fishes off the coast of Central America. Pac. Sci., 15(3) : 483.

Baldwin, W. J. 1961. First records of three northern fishes from the upper Gulf of California. Copeia, 1961 (4) : 475–476.

Becker, V. E. 1965. Fishes of the Indian Ocean and seas of southeastern Asia. The lantern fishes of the genus *Hygophum* (Myctophidae, Pisces). Systematics and distribution [In Russian]. Trudy Inst. Okeanologii, Akad. Nauk SSSR, 80 : 62–103.

Beebe, William, and Mary Vander Pyl. 1944. Eastern Pacific expeditions of the New York Zoological Society. 33. Pacific Myctophidae (Fishes). Zoologica, 29(9) : 59–95.

Best, E. A., and J. Gary Smith. 1965. Fishes collected by midwater trawling from California coastal waters, March 1963. Calif. Fish and Game, 51(4) : 248–251.

Bolin, Rolf L. 1939. A review of the myctophid fishes of the Pacific Coast of the United States and of Lower California. Stanford Ichthyol. Bull., 1(4) : 89–156.

——— 1959. Iniomi, Myctophidae from the "Michael Sars" north Atlantic deep-sea expedition 1910. Rept. Michael Sars N. Atl. Deep-sea Exped. 1910, 4(7) : 1–45.

Briggs, John C. 1960. Fishes of worldwide (circumtropical) distribution. Copeia, 1960 (3) : 171–180.

Bussing, William A. 1965. Studies of the midwater fishes of the Peru-Chile Trench. Am. Geophys. Union, Antarctic Res. Ser., 5 : 185–227.

Clemens, Harold B., and John C. Nowell. 1963. Fishes collected in the eastern Pacific during tuna cruises, 1952 through 1959. Calif. Fish and Game, 49(4) : 240–264.

Ebeling, Alfred W. 1962. Melamphaidae. I. Systematics and zoogeography of the species in the bathypelagic fish genus *Melamphaes* Günther. Dana-Rept., (58) : 1–164.

Fierstine, Harry L., and R. G. Werner. 1963. A new northern record of the smooth stargazer. Calif. Fish and Game, 49(1) : 50–52.

Fitch, John E. 1951. Studies and notes on some California marine fishes. Calif. Fish and Game, 37(2) : 111–120.

Fowler, Henry W. 1944. Results of the Fifth George Vanderbilt Expedition (1941). The fishes. Monogr. Acad. Nat. Sci. Phila., (6) : 57–583.

Fraser-Brunner, A. 1949. A classification of the fishes of the family Myctophidae. Proc. Zool. Soc. London, 118(4) : 1019–1106.

Ginsburg, Isaac. 1954. Whitings on the coasts of the American continents. Fish. Bull., U.S. Fish and Wildl. Serv., 56(96) : 187–208.

Grey, Marion. 1960. A preliminary review of the family Gonostomatidae, with a key to the genera and the description of a new species from the tropical Pacific. Bull. Mus. Comp. Zool. (Harvard), 122(2) : 57–125.

——— 1964. Family Gonostomatidae, p. 78–240. *In* Fishes of the western North Atlantic. Sears Found. Mar. Res., Mem. 1. no. 1, pt. 4.

Hildebrand, Samuel F. 1943. A review of the American anchovies (Family Engraulidae). Bull. Bingham Oceano. Coll., 8(2) : 1–165.

Hopkirk, John E. 1965. Records of yellow and spotted snake-eels (Genus *Ophichthus*) from San Francisco Bay, California. Calif. Fish and Game, 51(3) : 183–186.

Hubbs, Carl L., and Clark Hubbs. 1941. Pacific cutlassfish, *Trichiurus nitens* Garman. Calif. Fish and Game, 27(1) : 29–30.

Hubbs, Carl L., and Robert L. Wisner. 1964. *Parvilux*, a new genus of myctophid fishes from the northeastern Pacific, with two new species. Zool. Meded., 39 : 445–463.

Morrow, James E. 1957. Mid-depth fishes of the Yale South American Expedition. Bull. Bingham Oceano. Coll., 16(2) : 56–71.

Munro, Ian S. R. 1950. Revision of *Bregmaceros* with descriptions of larval stages from Australasia. Proc. Roy. Soc. Queensland, 59(5) : 37–53.

Parr, A. E. 1931. Deepsea fishes from off the western coast of North and Central America. Bull. Bingham Oceanog. Coll., 2(4): 1–53.

Phillips, J. B. 1957. A review of the rockfishes of California (Family Scorpaenidae). Fish Bull., Calif. Dept. Fish and Game, (104): 1–158.

Ramirez, Ernesto, N. Vazquez, R. Marquez, and C. Guerra. 1965. Investigaciones ictiologicas en las costas de Sinaloa. (I) Lista de peces colectados en las capturas camaroneras. Sect. Indust. Comer., Inst. Nac. Invest. Biol.-Pesq., 12: 1–36.

Schultz, Leonard P. 1953. Family Sphyraenidae: Barracudas (p. 279–287). *In* Schultz, L. P. and Collaborators, Fishes of the Marshall and Marianas Islands. Bull., U.S. Natl. Mus., (202): 1–685.

Tucker, Denys W. 1956. Studies on the trichiuroid fishes—3. A preliminary revision of the family Trichiuridae. Bull. Brit. Mus. (Nat. Hist.) Zool., 4(3): 73–130.

Whitehead, P. J. P. 1963. A revision of the recent round herrings (Pisces: Dussumieriidae). Bull. Brit. Mus. (Nat. Hist.) Zool., 10(6): 305–380.

Wisner, Robert L. 1962. Midwater trawl surveys. *In* Oceanographic studies during operation "WIGWAM." Limn. & Oceanogr., supp., 7: i-xci.

——— 1963. *Lampanyctus hubbsi*, a new myctophid fish from the east-central tropical Pacific Ocean, with notes on the related, sympatric eastern Pacific species, *L. omostigma* and *L. parvicauda*. Copeia 1963(1): 16–23.

Calif. Fish and Game, 52(2) : 111–116, 1966.

FECUNDITY OF THE PACIFIC HAKE, *MERLUCCIUS PRODUCTUS* (AYRES)[1]

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Measurements of yolked eggs in the developing ovaries of female hake formed bimodal distributions. The numbers of advanced yolked eggs increased with both length and weight of the fish. The smallest of 22 hake, 346 mm long contained 80,000 eggs, while the longest, 688 mm, contained 496,000 eggs: The number of eggs may be estimated by multiplying fish length cubed by 0.00142, or by multiplying weight by 192. Weights ranged from 300 to 2,750 g, and these fish contained 46,000 and 496,000 eggs respectively. There was considerable variation in numbers of advanced eggs produced regardless of size. A fish 395 mm long that weighed 500 g contained 298,000 eggs, while a larger specimen, 433 mm and 600 g, contained only 64,000 eggs. Although two sizes of yolked eggs were present in the ovaries, the peculiarities of the distribution and the relatively short spawning season indicate that the hake spawns only once a year.

INTRODUCTION

During the 15 years of the California Cooperative Oceanic Fisheries Investigations' surveys of the California Current area, Pacific hake have ranked second in abundance among larvae taken in plankton tows. Hake have accounted for about 19 percent of the total larvae taken; northern anchovy (*Engraulis mordax* Girard) larvae, the most abundant, have accounted for about 34 percent. To estimate the biomass of the parent stock of a fish species from the occurrence of eggs or larvae in the plankton, one must know the average number of times each female spawns in a year and the number of eggs produced at each spawning.

METHODS

My estimates of hake fecundity are based on 22 females with well-developed ovaries taken in March 1963 off northern Baja California. Standard length was recorded to the nearest millimeter and weight to the nearest 50 grams. The specimens were 346 to 688 mm long and weighed from 300 to 2,750 g (Table 1). Ovary weight ranged from 13.1 g in one of the small specimens to 196.8 g in the largest; both of these ovaries were at about the same developmental stage.

Frequency distributions of the diameters of eggs containing yolk were determined from ovarian samples. Each ovary contained a distinct group of large, yolked eggs plus a more or less distinct group, or groups, of small, yolked eggs. Ratios of numbers of larger eggs to smaller ones were determined from the frequency distributions.

The ovarian samples used to estimate egg numbers were larger than those used to obtain frequency distributions. The samples were weighed,

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and only the eggs in the most advanced stage of development were counted under a binocular microscope. Egg counts varied widely among different specimens without relation to ovary weight and egg size, so more than one count was made on ovaries showing high deviations from the number expected. Every additional count agreed with the first count for the same fish. These variations in egg counts appeared to be caused by differences in the amount of tissue other than yolked eggs, and by variations in size and numbers of the smaller, yolked eggs.

Of the 22 fish examined, 15 contained opaque, advanced eggs with mean diameters of 0.66 to 0.80 mm, and 7 contained translucent, advanced eggs with mean diameters of 0.84 to 1.12 mm; both of these groups of eggs formed distinct modes when frequencies were plotted. The translucent eggs were more distorted by preservative than the opaque eggs and therefore more difficult to measure. Ahlstrom and Counts (1955) reported that hake eggs taken in plankton tows had diameters of 1.07 to 1.18 mm. None of the ovaries containing translucent eggs appeared to be partly spent.

LENGTH AND FECUNDITY

There is an obvious relation between the number of eggs in an advanced stage of development and fish length, although there is considerable spread of values about the line fitted to the data (Figure 1). The greatest deviation is exhibited by a 395 mm hake that contained 278,000 advanced eggs, and one approximately the same size (391 mm) that contained only 71,500 eggs, or about one-quarter as many. Since the ovaries of the 395 mm hake weighed 3½ times as much as those of

TABLE 1

Fecundity Data for 22 Hake from Northern Baja California, March 1963

Standard length (mm)	Weight (grams)	Gonad weight (grams)	Advanced eggs		Eggs per gram of fish
			Number (thousands)	Diameter (mm)	
688	2,750	196.8	496	.60– .76	180
577	1,600	106.7	147	.56– .74	92
552	1,350	68.3	163	.58– .76	120
533	1,100	52.9	120	.60– .76	115
515	950	57.4	96	.80–1.00*	101
503	950	74.2	242	.64– .88	256
497	900	88.2	292	.68– .84	324
481	850	64.7	188	.70– .90	221
475	750	83.6	252	.70– .90	336
447	650	87.4	108	1.00–1.22*	166
442	600	43.8	137	.56– .74	228
433	600	42.9	64	.80–1.04*	107
431	600	49.9	93	.80–1.00*	155
422	550	41.2	122	.60– .80	221
395	500	82.0	278	.58– .76	556
391	400	24.8	72	.60– .80	179
384	350	18.5	43	.58– .78	122
373	400	13.1	38	.62– .80	96
367	400	13.7	33	.66– .82	83
358	450	51.4	113	.88–1.06*	251
351	300	30.0	46	.82–1.04*	153
346	500	45.4	80	.76– .92*	160

* Translucent eggs.

the 391 mm hake, and the advanced eggs of the 395 mm hake were smaller (mean diameter 0.68 mm) than those of the 391 mm fish (mean diameter 0.72 mm), the differences appear to be real.

WEIGHT AND FECUNDITY

The number of advanced eggs ranged from 33,000 in a 400 g hake to 496,000 in a 2,750 g hake. Advanced eggs per gram of female hake ranged from 83 to 556 and averaged 192. The relative fecundity (eggs per gram of fish) may be lower in large and small hake than in fish

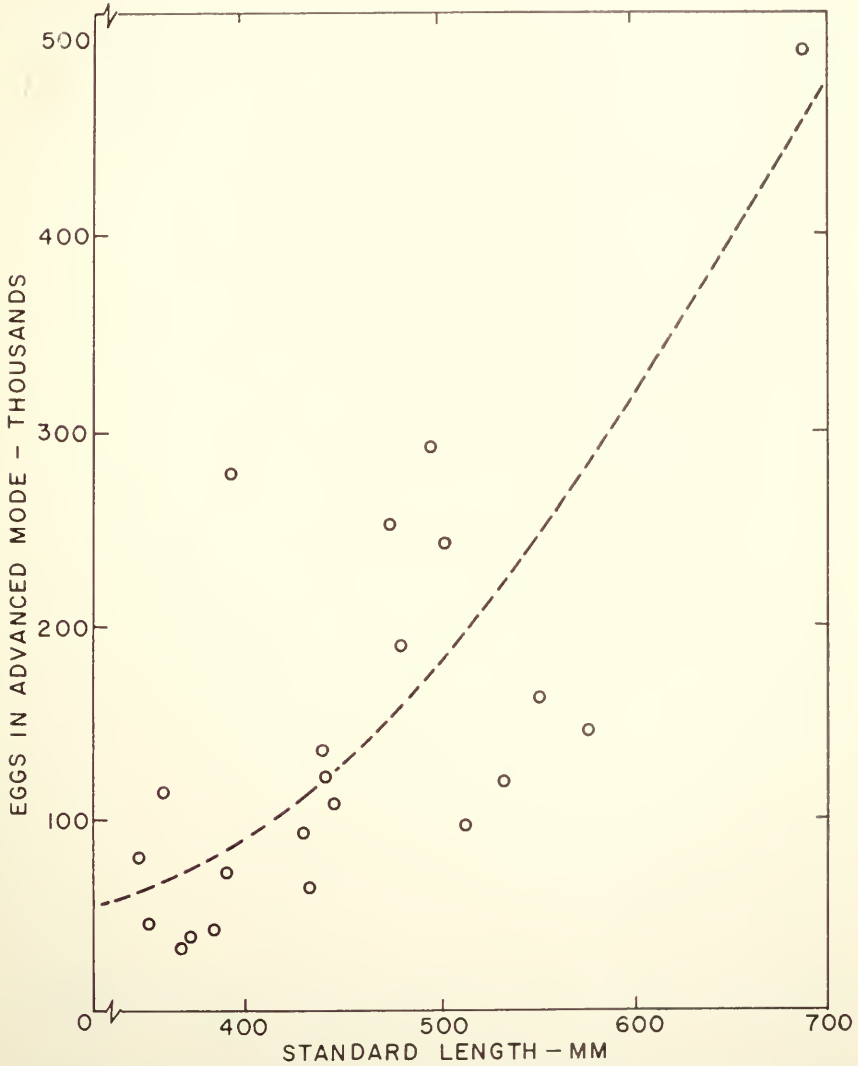

FIGURE 1. Estimates of numbers of advanced eggs in 22 hake ovaries plotted against standard length of female hake. The line describing the data is $Y_c = 0.00142X^3$ in which Y_c = the calculated numbers of eggs and X^3 = length of fish cubed.

of intermediate size (Figure 2). Eggs per gram of fish averaged 127 (range 83–179) for the 5 fish weighing 300–400 g, 127 (range 92–180) for the 4 fish weighing 1,100–2,750 g, and 237 (range 101–556) for the 13 fish weighing 450–950 g.

NUMBER OF SPAWNINGS

Ahlstrom and Counts (1955) found, from extensive plankton sampling off the coasts of California and Baja California in 1951 and 1952, that 50 to 60 percent of the hake larvae were taken in March, and 98

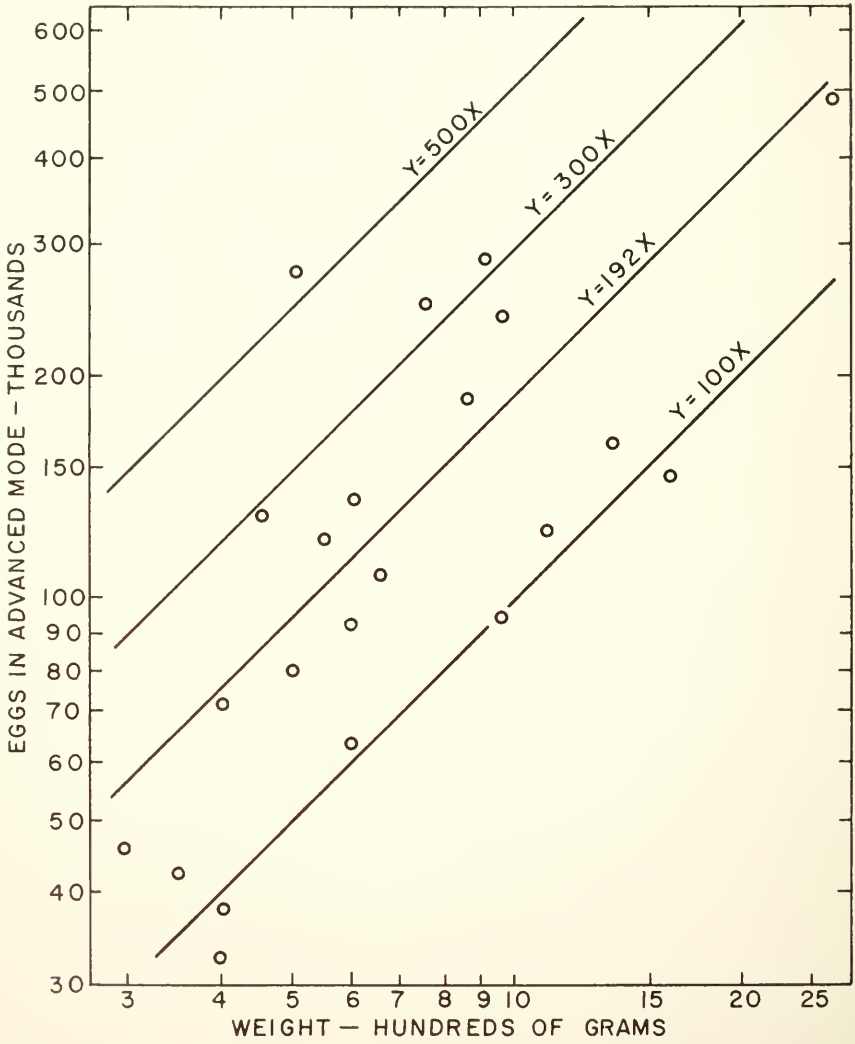

FIGURE 2. Estimates of numbers of advanced eggs in 22 hake ovaries plotted against weight of female hake. The lines represent 100 eggs per gram of fish, 192 (the average describing the sample), 300, and 500 eggs per gram of fish respectively.

percent in February, March, and April. Such a restricted spawning period would indicate that only one spawning occurred each year.

On the other hand, the presence of more than one size group of yolked eggs in the ovary has been interpreted by many investigators to indicate that more than one spawning may occur per year. The ratios of numbers of advanced eggs to smaller eggs varied considerably among the 22 hake examined. The ratios of large to small eggs for three hake were approximately 1:2.5, 1:0.5 and 1:0.25 (Figures 3A, 3B, 3C). The 1:2.5 ratio (Figure 3A) represents a hake with a very low relative fecundity, 92 advanced eggs per gram of fish, while the 1:0.5 ratio (Figure 3B)

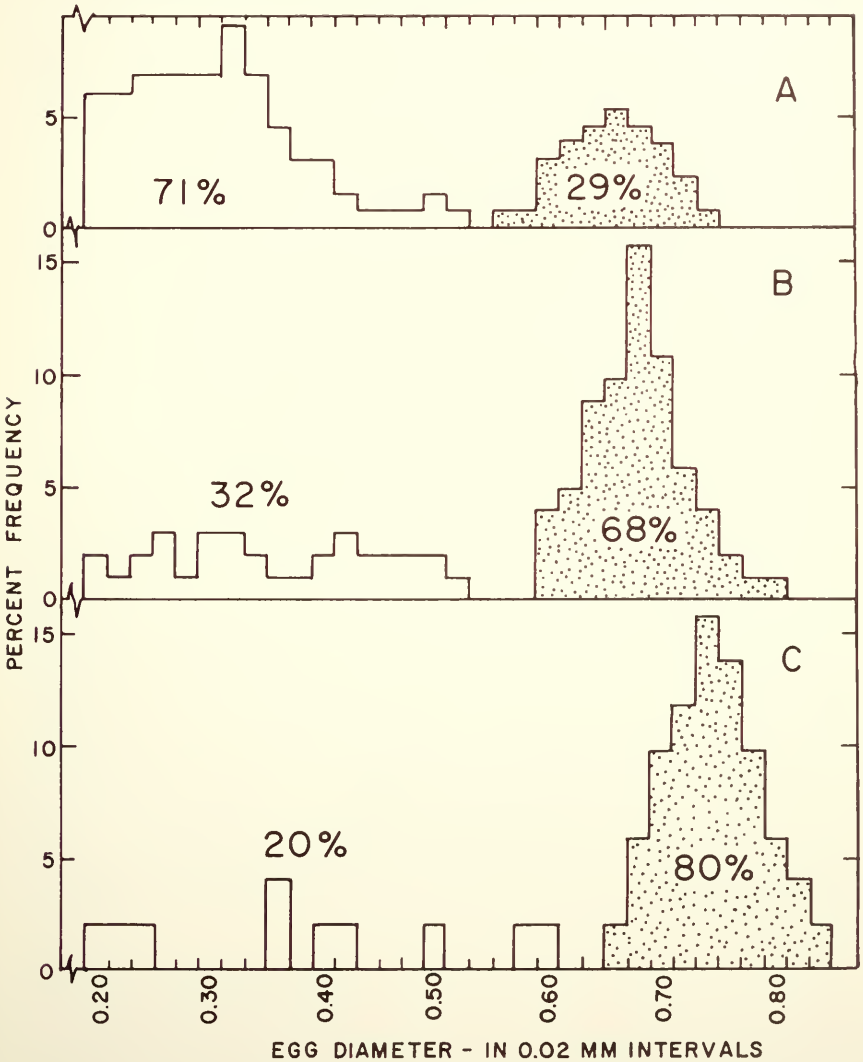

FIGURE 3. Frequency distributions of yolked eggs found in three different hake ovaries illustrating differences in ratios between small yolked and advanced yolked eggs.

represents an intermediate value, 221 eggs per gram of fish, and the 1:0.25 ratio (Figure 3C) a high value, 324 eggs per gram of fish. If total eggs are considered, the eggs per gram of fish are relatively much closer—315, 327, and 403, respectively.

The advanced group of eggs made up 50 percent or less (17–50 percent) of the total number of yolked eggs in 10 hake, and 51 percent or more (51–83 percent) in 12 hake. None of the hake in the first group had as many as 175 eggs per gram of fish, but 10 of the 12 fish in the latter group contained more than 175. The correlation coefficient between percentage of eggs in the advanced mode (X) and advanced eggs per gram of fish (Y) ($Y_c = 36.4 + 3.04X$) is 0.53; the probability that such a correlation could occur by chance alone is approximately 1 in 100 (0.01).

The existence of a correlation between eggs per gram of fish and percentage of yolked eggs in the advanced mode makes multiple spawning seem unlikely. It does not appear that a fish of high relative fecundity would spawn up to 83 percent of the yolked eggs in one batch, and then develop the remaining smaller percentage of the eggs for a subsequent spawning. Similarly, a fish of low relative fecundity which was unable to develop more than 17 percent of its yolked eggs to an advanced stage, would hardly be expected later to develop the relatively large numbers of remaining eggs. The largest average-sized opaque eggs, 0.80 mm diameter, have almost 2.5 times the volume of 0.60 mm eggs, 8 times the volume of 0.40 mm eggs, and 64 times the volume of 0.20 mm eggs. (The increase in size of translucent eggs above 0.80 mm diameter appears to be the result of water intake rather than the addition of nutrient yolk material.) In general, gonad development appears to exert a considerable drain on the body resources of the fish. In the present study, material to establish criteria of condition was lacking, but the hake all appeared to be very thin and in poor condition. The probability would appear to be slight that these fish could produce the large volume of yolk material necessary to develop additional eggs to spawning size subsequent to spawning of the advanced eggs in the ovaries.

The short spawning season, the relationship between eggs per gram of fish and percentage of yolked eggs in an advanced stage of development, and the poor condition of the fish coupled with the considerable volume of yolk material that would be needed to develop a second spawning batch, indicate that the hake spawns once a year. The small yolked eggs remaining after the advanced group has been spawned are, no doubt, resorbed.

REFERENCES

Ahlstrom, E. H., and R. C. Counts. 1955. Eggs and larvae of the Pacific hake *Merluccius productus*, U.S. Dept. Interior, Fish and Wildlife Service, Fish. Bull., 56(99): 295–329.

NOTES

A SEXUALLY ABNORMAL RED CRAB, *CANCER PRODUCTUS* RANDALL

On October 25, 1965, while conducting the California Department of Fish and Game pre-season crab survey, a pair of mating red crabs was taken at lat. 37° 49.2′N., long. 122° 47.2′W., in 25 fathoms in a commercial crab trap. The male, 127 mm in shoulder width, was clutching a 101 mm female. The female had three vaginal openings, two in the normal position on the segment bearing the third walking legs, and one on the right side of the segment bearing the second walking legs (Figure 1).

Dissection showed that the extra opening was a blind sac, leading to the vagina and seminal receptacle in a normal manner, but terminating with an oviduct 8 mm long; the flaccid seminal receptacle did not contain sperm.

The two normal seminal receptacles were turgid and full of sperm. The light-orange ovary was in the early stages of development.

FIGURE 1. Underside of female *Cancer productus* showing three vaginal openings. *Photo by the author.*

—Richard Poole, Marine Resources Operations, California Fish and Game, December, 1965.

RECENT SIGHTINGS OF BLACK BRANT *(BRANTA NIGRICANS)* IN THE SALTON SEA AREA OF SOUTHERN CALIFORNIA

The black brant historically has confined its overland migrations to a narrow strip immediately adjacent to the Pacific Ocean. It has been known to depend primarily on eel grass (*Zostera marina*) for its winter food. Eel grass is found in shallow bays and estuaries along the Pacific coast, but has declined greatly in southern California because of extensive dredging and other man-made developments.

In early April 1963, a flock of more than 100 black brant was sighted at the north end of Salton Sea, California, nearly 90 miles from the coast. Another large flock of about 225 was reported at the Salton Sea National Wildlife Refuge at the south end of the Sea in the spring of 1964. On May 10, 1965, 60 were seen on Ramer Lake, Imperial State Waterfowl Management Area, just southeast of Salton Sea.

Numerous other sightings of smaller groups and single birds have been made in the Salton Sea area during and since 1962. In late summer several brant have been found that were unable to fly because of their post-nuptial moult.

The Salton Sea brant have been reported feeding on bulrush, probably the alkali bulrush *(Scirpus robustus)* which is abundant in the area.

—*Forrest L. Reynolds, Game Management Branch, California Department of Fish and Game, November 1965.*

SEA LION CENSUS FOR 1965 INCLUDING COUNTS OF OTHER CALIFORNIA PINNIPEDS

The sea lion populations along the California coast have been counted intermittently since the late 1800's. Censuses have been made by the Department of Fish and Game since 1927. Ripley, Cox, and Baxter (1962) detailed the methods, problems, and history of sea lion censusing in California.

In the present census, made June 1–3, 1965, all pinniped species (California sea lions, *Zalophus californianus;* Steller sea lions, *Eumetopias jubata;* harbor seals, *Phoca vitulina;* and northern elephant seals, *Mirounga angustirostris*) were counted. No attempt was made to distinguish between the two species of sea lions; those north of Point Conception were considered Stellers, and those south, California sea lions. The two overlap only to a limited degree in central California during the breeding season (the period of our census).

The census area included the entire California coast and offshore islands, except for military closures off Fort Ord on Monterey Bay, and from Point Sal to Point Conception. Normally, very few animals occur in these areas.

A twin-engine Beechcraft was used and visual counts were made of small aggregations, but large herds were photographed with a K-17 aerial camera.

SEA LIONS

The decrease in total numbers of sea lions since 1961, as indicated by the 1965 count of 22,167, is probably not significant. The 11.5 percent difference could be due to counting error, but the larger proportionate decrease in northern California suggests a decline in sea lion numbers has occurred (Table 1).

TABLE 1

Comparison of Sea Lion Distribution on Rookeries and Hauling Grounds, 1961 and 1965

Locality	Number		Locality	Number	
	1961	1965		1961	1965
Northern California			**Southern California**		
St. George Reef to Cape Mendocino	907	625	Point Conception to Point Loma	33	67
To Point Arena	781	278	San Miguel Island	9,512	11,641
To Point Reyes	795	259	Santa Rosa Island	..	125
To Pigeon Point	23	0	Santa Cruz Island	15	401
Farallon Islands	703	311	Anacapa Island	15	..
Point Ano Nuevo	2,342	2,574	Santa Barbara Island	1,760	1,100
To Point Lobos	230	317	San Clemente Island	2,361	1,900
To Point Conception	894	634	Santa Catalina Island	30	35
			San Nicolas Island	4,637	1,900
Total for northern California	**6,675**	**4,998**	**Total for southern California**	**18,363**	**17,169**

Statewide total 1961 – 25,038

Statewide total 1965 – 22,167

NORTHERN ELEPHANT SEALS

Of greater significance than the fluctuation in the sea lion population, is the large increase in numbers of elephant seals. Unpublished reports, including that of the 1961 census (John L. Baxter, pers. commun.), have noted about 800 on San Miguel Island. A recent count made by one of us (JGC) on San Miguel Island verified the 3,000 recorded in 1965 (Table 2). This constitutes a notable recovery for the elephant seal after having been reduced to near extinction by sealing in the 19th century.

HARBOR SEALS

Harbor seals were included in the 1965 census because no reliable estimate of their population was available. The 1,062 we counted did not include the animals known to occur in San Diego Bay. Numerous low-flying aircraft precluded censusing in this area (Table 3).

REFERENCES

Orr, Robert T. and Thomas C. Poulter. 1962. Año Nuevo Marine Biological Park. Pac. Disc., 15(1): 13–19.

Radford, Keith W., Robert T. Orr and Carl L. Hubbs. 1965. Reestablishment of the northern elephant seal (*Mirounga angustirostris*) off central California. Calif. Acad. Sci. Proc., 31(22): 601–612.

Ripley, Wm. Ellis, Keith W. Cox and John L. Baxter. 1962. California sea lion census for 1958, 1960 and 1961. Calif. Fish and Game, 48(4): 228–231.

—*John G. Carlisle, Jr., and J. A. Aplin, California Department of Fish and Game, Marine Resources Operations, October 1965.*

TABLE 2

Distribution of 3,563 Northern Elephant Seals During 1965 Census

Locality	Number
Año Nuevo Island	363
San Miguel Island	3,000
San Nicolas Island	100
San Clemente Island	100

TABLE 3

Distribution of 1,062 Harbor Seals Counted During 1965 Census

Locality	Number	Locality	Number
Humboldt Bay	6	Point Reyes	8
Bear River	50	Bolinas Bay	230
Mattole River	130	Point Montara	20
Mistake Point	105	Monterey	94
Fort Bragg	35	Partington Point	25
Point Arena	34	Point Piedras Blancas	25
South of Gualala River	30	North of Cayucos	20
Russian River	5	San Miguel Island	140
omales Point	35	Santa Cruz Island	70

THE POACHER *ASTEROTHECA INFRASPINATA* (GILBERT) ADDED TO CALIFORNIA'S MARINE FAUNA, AND A KEY TO CALIFORNIAN AGONIDAE (PISCES)

Poachers are common constituents of trawl catches throughout Californian coastal waters, particularly at depths exceeding 30 fathoms (55 m). The finer the mesh used, the greater the catch of agonids. Often during shrimp *(Pandalus jordani)* trawling operations off northern and central California, four or more kinds of agonids will be netted in a single haul. The blacktip poacher, *Xeneretmus latifrons*, typically is the most common member of the family on the shrimping grounds, but bluespotted poachers, *Xeneretmus triacanthus*, warty poachers, *Occa verrucosa*, pygmy poachers, *Odontopyxis trispinosa*, and northern spearnose poachers, *Agonopsis emmelane*, also are present in fair numbers.

On May 19, 1962, during a preseason shrimp cruise aboard the Department of Fish and Game research vessel *Alaska*, a single *Asterotheca infraspinata* turned up among two dozen *Xeneretmus latifrons* and a fair quantity of shrimp caught in 86 fathoms (157 m), 15.0 miles NW of Rocky Point (lat. 41° 19′N., long. 124° 24′W.), Humboldt County, California. It was recognized immediately as being different from other agonids known from our waters, but because of inadequate published descriptions, lack of a good family key, and an ill-chosen common name, its specific identity remained undetermined until comparative material was borrowed through the U.S. Bureau of Commer-

TABLE 1

Selected Measurements (in Percent of Standard Length) and Counts on Three Species of *Asterotheca*

	A. infraspinata	*A. alascana*	*A. pentacantha*
Measurements:			
Standard length (mm)	88–112	90–106	133–147
Head length	22.0–24.1	22.2–24.0	21.4–22.5
Snout length	5.7–6.3	5.6–6.7	5.9–6.8
Bony orbit length	7.3–8.9	8.5–9.1	8.2–8.5
Snout to 1st dorsal insert	34.1–36.6	33.9–36.5	30.1–30.8
D_1 insert to end of hypural	65.7–67.0	63.4–66.9	69.9–71.6
D_2 insert to end of hypural	48.9–51.1	44.2–48.1	48.0–50.4
Counts:			
D_1	V–VI	VI–VII	VII–VIII
D_2	6	5–7	6–7
Anal fin	5–8	6–8	7–8
Pectoral fin	15–16	15	15–16
Median dorsal plates	14–16	13–14	16–17
Total plates, dorsal series	35–38	37–39	42–44
Vertebrae (precaudal & caudal)	13 + 28 = 41	40–41*	12 + 33 = 45
Number of specimens	**5**	**4**	**6**

* Total vertebrae.

cial Fisheries, Seattle, Washington. No additional specimens were found in catches from subsequent shrimp trawling operations until October 1965, when great numbers were taken off northern California during Cruise 6586 of the *N. B. Scofield* (Daniel W. Gotshall, pers. commun.). Several of these were saved and direct comparisons were made with the other two eastern Pacific species *A. pentacanthus* and *A. alascana* (Table 1).

The choice of "spinycheek starsnout" as a common name by the American Fisheries Society (1960) and Clemens and Wilby (1961) is unfortunate, in that the cheek of *A. infraspinata* is no more spiny than that of a dozen other eastern Pacific agonids. The spines that distinguish *A. infraspinata* border the lacrymal anteriorly on either side of the median rostral plate. While they also are on the lateral angles of the snout, these spines could not possibly be mistaken for "cheek" spines, even in th broadest interpretation of that part of the fish's anatomy. Obviously "spinysnout starsnout" is awkward, and "spinynose starsnout" will be looked upon with disfavor by the purist, but not much leeway is available to describe adequately this diagnostic character with a single adjective (e.g., spinyfaced, spinyfronted, spinylacrymal, etc.).

In view of the frequency with which poachers are captured, and the infrequency with which they are listed by species, a simple key to their identification seems appropriate. Except for *Stelgis vulsa*, the key presented here is based upon first-hand examination of all the species known from California. In the case of *Xeneretmus leiops*, I have seen only four freshly caught individuals, and of *Pallasina barbata*, first reported in our waters by Hemphill and Follett (1958), I have seen specimens only from Bodega Bay, California; otherwise, more than 10 individuals of each species have been seen, and these have been from more than one locality. The key will not work for pelagic postlarvae and early juveniles that sometimes are caught in plankton nets.

KEY TO CALIFORNIAN AGONIDAE

1 Plates on body smooth 2
Plates on body spiny 3

2 Body short; head broad; occiput with a deep pit; snout normal
Bothragonus swani (Steindachner)
Body long, slender; head narrow; occiput without pit; snout tubular ..... *Pallasina barbata* (Steindachner)

3 Gill membranes free from isthmus, with a posterior free fold at least as wide as diameter of orbit 4
Gill membranes attached to isthmus, but sometimes with a very narrow fold porteriorly 5

4 Breast with fairly large, well-defined bony plates; D. VII–IX, 7–8; A. 10–12; P. 14–15 ..... *Occa verrucosa* (Lockington)
Breast covered by an even, coarse felt of small spines; D. VI–VII, 6–7; A. 8–9; P. 17–19
Stellerina xyosterna (Jordan and Gilbert)

5 Tip of snout terminating in two short spines projecting forward; no movable, terminal rostral plate 6
Tip of snout with a movable, terminal rostral plate bearing one or more upright spines 8

6 Vomer without teeth ..... *Stelgis vulsa* (Jordan and Gilbert)
Vomer with teeth 7

7 Cirri below rostral spines and along lower preorbital margin ..... *Agonopsis emmelane* (Jordan and Starks)

No cirri below rostral spines or on preorbital margin ..... *Agonopsis sterletus* (Gilbert)

8 Occiput with an abrupt deep pit; no occipital spines ..... *Odontopyxis trispinosa* Lockington
Occiput without a distinct pit; two pairs of occipital spines 9

9 Rostral plate with three erect spines in addition to those at the lateral angles 10
Rostral plate with only one erect spine 11

10 Front of lacrymal smooth, without spines; 41 to 44 plates in the dorsal series ..... *Asterotheca pentacantha* (Gilbert)
Front of lacrymal bordered with sharp, forward-projecting spines; 35 to 39 plates in the dorsal series ..... *Asterotheca infraspinata* (Gilbert)

11 Cheek below suborbital stay with two or three bony plates; P. 13; small blue spots on head and anterior trunk; dorsal fins nearly lacking in dusky pigment ..... *Xeneretmus triacanthus* (Gilbert)
Cheek below suborbital stay naked, without plates; P. 14–16 (rarely 13 on one side); no blue spots on head or trunk; dorsal fins with dusky pigment 12

12 Two cirri on end of maxilliary; a black band on base of dorsal as well as margin, area between whitish; P. 16 ..... *Xeneretmus ritteri* (Gilbert)
A single cirrus on end of maxillary; no black on base of dorsal fins; P. 14 13

13 Three to five spinous scales on eyeball; black margin on tips of dorsal rays, uniform in width; 14 to 16 plates in median dorsal series behind 2nd dorsal ..... *Xeneretmus latifrons* (Gilbert)
No spines on eyeball; black blotch on tips of anteriormost dorsal rays, disappears porteriorly; 17–18 plates in median dorsal series behind 2nd dorsal ..... *Xeneretmus leiops* Gilbert

I sincerely appreciate the assistance of the many Department employees who have saved agonids for me throughout the years, especially John L. Baxter, Daniel W. Gotshall, and Tom Jow. Richard B. Grinols, U.S. Bureau of Commercial Fisheries, Seattle, loaned me comparative material from northern waters, and Keith Radford, Scripps Institution of Oceanography, La Jolla, made X-rays of several specimens for me, as did Robert J. Lavenberg, Los Angeles County Museum of Natural History.

REFERENCES

American Fisheries Society. 1960. A list of common and scientific names of fishes from the United States and Canada, 2nd Edit. Am. Fish. Soc., Spl. Publ., (2): 1–102.

Clemens, W. A., and G. V. Wilby. 1961. Fishes of the Pacific coast of Canada, 2nd. edit. Fish Res. Bd. Canada, Bull., (68): 1–443.

Hemphill, Donald V., and W. I. Follett. 1958. First record of the agonid fish *Pallasina barbata aix* Starks from California. Calif. Fish and Game, 44(3): 281–283.

—— *John E. Fitch, Marine Resources Operations, California Department of Fish and Game, Terminal Island, December 1965.*

ADDITIONAL RECORDS OF FLAPJACK DEVILFISH FROM CALIFORNIA WATERS

On March 11, 1965, a male flapjack devilfish, *Opisthoteuthis californianus,* measuring 18 inches (457 mm) between the tips of the radially-stretched arms, was taken at a depth of 270 fathoms (494 m) off Pt. Lobos, south of Monterey Bay by Capt. Joe Pennisi and crew of the otter trawler *San Giovanni.*

There is only one previous record of this cephalopod from as far south as the Monterey region (Phillips, 1961). All other captures have been made near Eureka, about 300 miles north of Monterey. The original description and first records of this unusual octopus in our waters were by Berry (1949, 1952, 1955).

The frequency of capture of this species appears to be in direct ratio to the number of deep-water hauls made by otter trawlers. During September and October 1964, 10 of these web-footed octopi were taken between Eureka and Trinidad Head at depths of 285 to 317 fathoms (521–580 m) by the crew of the trawler *New St. Joseph.* Concurrently, a giant squid, *Moroteuthis robusta,* and a ribbonfish, *Trachipterus altirelis,* were caught at these depths (Daniel Gotshall, pers. comm.).

Of 16 flapjack devilfish for which depth and locality of capture are known, only one was taken shallower than 250 fathoms (457 m), the exception being 188 fathoms (344 m). Hauls as deep as 250 fathoms have been infrequent in the past.

LITERATURE CITED

Berry, S. Stillman. 1949. A new *Opisthoteuthis* from the eastern Pacific. Leaflets Malacology, 1(6): 23–26.

——— 1952. The flapjack devilfish, *Opisthoteuthis,* in California. Calif. Fish and Game, 38(2): 183–188.

———1955. The male flapjack devilfish. Calif. Fish and Game, 41(3): 219–224.

Phillips, Julius B. 1961. Two unusual cephalopods near Monterey. Calif. Fish and Game, 47(4): 416–417.

—— *Julius B. Phillips, Marine Resources Operations, California Department of Fish and Game, October, 1965.*

BOOK REVIEWS

A Glossary of Ocean Science and Undersea Technology Terms

Edited by Lee M. Hunt and Donald G. Groves; Compass Publications, Inc., Arlington, Va., 1965; 172 p., illustrated; $5.95.

Whoever thought up this glossary certainly had the right idea for a helpful and much-needed reference. I didn't count the entries, but the publisher assures the reader it is "an authoritative compilation of over 3,500 engineering and scientific terms used in the field of underwater sound, oceanography, marine sciences, underwater physiology and ocean engineering." The 131 pages comprising the glossary proper are followed by an appendix containing a wide assortment of useful data. Some of the 43 tabular presentations in this appendix are entitled: "Gross properties of sea water," "Characteristics of individual seas," "Acoustic absorption coefficient nomogram," "U.S. Navy standard air decompression table," and "Scientific information activities of the Department of the Navy."

The definitions given for the seemingly thousands of letter combinations that are the fad for designating expeditions, vessels, groups, and such (EASTROPIC, DDR,CalCOFI, etc.) are especially timely in that it has become impossible to keep track of these abbreviations any other way.

For most terminology, the source of the definition is given. While this does help trace the explanation of a term to its "author," it doesn't assure that the best source was consulted. The same criticism will hold for some of the tabular data in the appendix.

Although this glossary is a "first effort," it takes practically no searching to find typographical errors and errors of omission, and inadequate or controversial definitions crop up with some regularity. A couple of examples will illustrate these points: Coring devices are discussed and illustrated, but the definition of "core" does not include the sediment sample obtained with a coring device; the Davidson Current has been given a new starting point for its northward journey. And so it goes!

It would be nice if a group of authorities (acting as a committee?) could review the definitions before a second edition is published, and reach an agreement as to the completeness and accuracy of each explanation.—*John E. Fitch.*

Mammals of the Pacific States: California, Oregon, and Washington

By Lloyd G. Ingles; Stanford University Press, Stanford, Calif., 1965; 506 pages, illustrated; $10.

This excellent volume has little resemblance (externally) to its earliest predecessor, *Mammals of California*, published in 1947, or to the later edition entitled *Mammals of California and Its Coastal Waters*. Internally, many of the fine photographs which illustrated the 1947 edition are still in use, but the text has been refined, rearranged, and expanded.

Maps of the three Pacific states, with counties clearly outlined, grace the insides of the covers and their facing pages, and scales in centimeters and inches have been provided for handy reference. The first chapter, entitled "Mammals and Mammalogy," gives background information on the science of mammalogy, distinguishing characters, and classification. Following chapters discuss mammalian ecology and their paleontologic record. An artificial generic key to mammalian skulls, except Cetacea, is presented in the chapter entitled "The Study of Mammals."

Most of the book is devoted to species accounts, arranged by Order from Marsupialia to Artiodactyla. Brief descriptions are given for each species, and these are supplemented by dichotomous and pictorial keys, range maps, drawings, and photographs. General discussions of individual species, groups of species, or larger categories contain loads of intimate details on life history, habitats, behavior, importance, and so on.

Except for a selected bibliography and the index, a half-dozen appendixes complete the volume. These concern collecting and preparing specimens for study, scats, pronunciation of generic names, principles of zoological classification, dental formulae,

and a classification and checklist of native and introduced species. Perhaps by the time a fourth edition rolls off the press, an improved system will have been found for depicting seats. The sketchy, two-dimensional drawings reposing on pages 460 to 468 fail to demonstrate the potential importance of fecal droppings for recognizing their "owners."—*John E. Fitch.*

The Art of Plug Fishing

By Homer Circle; Stackpole Books, Harrisburg, Pa., 1965; 224 p., illustr., $6.95.

Novice and intermediate freshwater fishermen will find this book most informative and entertaining. It is written in a pleasant style by an author known to many as the Special Features Editor of *Sports Afield* magazine. The book deals with artificial lures, and fishing for sunfish, crappie, bass, pike, perch, and trout in rivers and lakes. Special emphasis is placed on plugging in warmwater lakes. The book is divided into five main chapters: (i) "Being an artful fisherman," (ii) "Selecting your tackle," (iii) "Plugging techniques," (iv) "Facts about fishes," and (v) "Tricks of the experts." Each chapter is sub-divided into specific subjects such as: how to find fish; best times to catch fish; when, where, and how to catch big bass; fishing rods and reels; knots; how colors and sounds affect fish; small versus large plugs; learning to work plugs; trolling; casting; and fish swimming speeds. Identifications, life histories, and ways to catch key game fishes are also presented. One of the most entertaining sections titled "Screwballs catch more fish" describes unusual fishing methods. The table of contents is excellent and can be used with the accuracy of an index. Besides listing all subjects in the table of contents, boldface type is used in the text for easy reference.—*James W. Burns.*

Handbook of California Birds

By Vinson Brown and Henry G. Weston, Jr.; Naturegraph Publishers, Healdsburg, Calif., 1965; 156 p., illustrated; $2.95 (paper).

Handbook of California Birds is one of a growing series of handbooks or field guides published by the Naturegraph Company dealing with the natural sciences of the western United States, with particular emphasis on California. The book's physical dimensions ($5\frac{1}{16} \times 8\frac{1}{16}$ inches), format, and general organization are all aimed at producing a practical and usable guide for field identification of birds.

This book is unique in that bird identifications can be approached by any of several methods: (i) size, shape, color, and general silhouettes; (ii) behavioral patterns; (iii) habitat associations; and (iv) song and sounds.

Almost all of the 368 species listed are illustrated with detailed black and white sketches or silhouettes. Opposite each page of illustrations (color plates excepted) are the appropriate names and word descriptions of the birds. Key identifying characteristics are highlighted in the diagrams or underscored in the text.

Field guides usually attempt to cram a maximum of information into a minimum space, and *The Handbook of California Birds* is no exception. The material has a crowded appearance. The habitat listings for each species (found on the page margins) frequently run together, and some important diagrams run to the edge of the page—a few were even trimmed or cut off (at least in the review copy). Use of the book under adverse field conditions is impaired by such awkward arrangements as dividing the all-important key to abbreviations so that it appears in two different places. Furthermore, each group is in the form of a paragraph rather than an outline thus making it awkward to read and decipher. A number of errors and omissions reduce the overall effectiveness of this handbook.

The publisher describes this 1965 edition as new, revised and with ". . . a large number of new and improved pictures, improvement of color in the color plates and corrections of errata . . . ." A page by page comparison with the 1961 edition, (a cloth backed copy), reveals marked improvements in the color plates as well as in the black and white sketches and photographs of habitat. Some of the outstanding errors were corrected. However, I could not find a single sketch or photo that was not in the first edition.

The amateur or beginning ornithology student interested in California birds will find this handbook useful—despite the shortcomings noted above.—*Leo Pinkas.*

The Animal Kingdom

By Robert T. Orr; The MacMillan Company, New York, 1965; 380p., illustrated; $9.95.

The Animal Kingdom was prepared to acquaint the nontechnical reader with the "inexhaustible variety of animal life" inhabiting the earth. To accomplish this end, two very brief chapters, "Classification" (2 pages) and "Animals in time" (4 pages), are used to set the stage for a systematic discussion of the phyla comprising the animal kingdom. The geological time table on page 25 helps explain the paleontological information around it, but I couldn't find any ready explanation for the inference that fossil-bearing formations contain uranium and lead which are used to determine the age of the interred fossils.

Obviously, with hundreds of thousands of kinds of animals inhabiting the earth, one shouldn't expect a complete treatise in a mere 380 pages, especially when 275 superb photos (32 in full color) are included. Regardless, enough information is presented for major groups within each phylum, and for typical and atypical species within these groups, to give the reader a good background knowledge.

If the details in the other chapters are as inclusive as they are in the fish section (and I have no reason to believe they aren't), the reader is in for some pleasurable and informative sessions. However, I was a bit shocked to see that the "speckled sanddab" peering forth from page 195 was right-eyed, and further on, the "bottlenosed dolphin leaping high out of the water" (page 334) looks suspiciously like a spinner porpoise.—*John E. Fitch.*

Home in Your Pack, The Modern Handbook of Backpacking

By Bradford Angier; Stackpole Books, Harrisburg, Pa. 1965; 192 pages, illustrated, $4.50.

Stackpole says that Bradford Angier comes indoors only to write about the outdoors. In addition to this book, Angier has authored or co authored 8 others and the titles of these indicate he is emminently qualified to write about backpacking and the art of living on the trail.

Each chapter is a complete story about an important phase of backpacking. For example, under the subject of clothing, foot gear (socks, insoles, high-top boot canvas shoes, rubber bottom-leather top boots, cleated and hob-nail soles, moccasins, leather treatment and foot care) is fully discussed. Items on jackets, pockets, rainwear, kerchiefs, windbreakers and comfort in cold country complete the chapter.

Chapter seven, "Modern hiker's first aid kit," is written by R. Russel Kodet, M.D. Dr. Kodet offers ideas about a back-packer really needs for first aid. Being an outdoorsman, his suggestions ring a bell that has needed ringing.

The satisfactory thing about this book is that down-to-earth discussions answer the questions campers, back-packers and other outdoor people are so puzzled about. A beginner can have full confidence in what he reads, and others will find intriguing solutions to many camping problems, whatever their experience.—*Parke H. Young.*

The Giant Canada Goose

By Harold C. Hanson; Southern Illinois Univ. Press, Carbondale, 1965; xxiii + 226 p., illustrated; $9.75.

Twenty-pound Canada geese with wing-spans exceeding 6 feet really do exist. This volume presents facts about a race of living giants (*Branta canadensis maxima*) thought to be extinct for over three decades.

This rediscovery came about because Dr. Hanson, who has studied Canada geese for 20 years, became puzzled by a flock of wintering geese in a city park. The size and color of these birds seemed different than the Hudson Bay Canada goose that he had become so familiar with.

The reader is given a report of Dr. Hanson's findings, chapters on the history of discovery, physical characteristics, breeding, range, migration, nesting, growth and development, foods and feeding habits, parasites, behavior, productivity and regulation of populations, management, and other pertinent topics.

Although this book was not written for the general reader, I would not discourage anyone with an interest in wildlife to pass up reading it. It is a valuable and interesting scientific publication. The technical tables, chapters on age, sex and sexual maturity, endoparasites and such, could be skipped by anyone just interested in

waterfowl in general, and they could still enjoy much of the less technical aspects. For example: the relationship between the increase in muskrats and the increase in the number of Canada geese; who leads the flocks; where these natives of upper inland North America go in winter (including trips to California), and the 48 pages of excellent photographs of these magnificent geese and their habitat are of general as well as scientific interest.

The author estimates there are about 55,000 giant geese in Canada and the United States exclusive of perhaps 7,000 birds held under federal permits. Dr. Hanson expresses hope they will increase and can be restored to much of their original range. He discusses the kind of action that should be taken to assure that these re-discovered birds will not be lost for certain in the future.—*William F. Hart.*

Fresh-Water Fishing

By Ed Moore; the Macmillan Co., New York, 1965; 159 p., illustr., $3.95 paperback.

This little paperback volume is written for the potential angler who has never wet a line in the pursuit of underwater prey. It deals entirely with the elementary concepts of fresh-water fishing. A basic discussion of the various types of fishing equipment and their uses is given. Brief life histories of a few of the important North American game and rough fishes are included. Six pages are devoted to the various types of boats, boat handling, safety precautions, and weather forecasting. A brief chapter discusses conservation laws and concepts. The book lacks an index and bibliography. The few diagrams that are included are of fair quality.

—*Michael L. Johnson.*

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FISH AND GAME COMMISSION

State of California

Notice is hereby given that the Fish and Game Commission shall meet on April 1, 1966, at 10 AM, in the Auditorium, Resources Building, 1416–9th Street, Sacramento, California, to receive recommendations from its own officers and employees, from the Department of Fish and Game and other public agencies, from organizations of private citizens, and from any interested person as to what, if any, orders should be made relating to birds or mammals, or any species or variety thereof for the 1966 hunting season.

Notice is hereby given that the Fish and Game Commission shall meet at 10 AM on April 29, 1966, in Room B109, State Building, 1350 Front Street, San Diego, California, for public discussion of, and presentation of objections to, the proposals presented to the Commission on April 1, 1966, and, after consideration of such discussion and objections, the Commission shall publicly announce the regulations it proposes to make relating to birds or mammals, or any species or variety thereof, for the 1966 hunting season.

Notice is hereby given that the Fish and Game Commission shall meet on May 27, 1966, at 10 AM, in Room 1138, New State Building, 107 South Broadway, Los Angeles, California, to hear and consider any objections to its determinations or proposed orders in relation to birds and mammals for the 1966 hunting season, such determinations resulting from hearing held on April 29, 1966. This notice is published in accordance with the provisions of Section 206 of the Fish and Game Code.

MONICA O'BRIEN
Secretary to the Commission

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